JANUARY 1931.] [Price 10s.

PROCEEDINGS

OF

THE LINNEAN SOCIETY OF LONDON.

142ND SESSION.

FROM NOVEMBER 1929 TO MAY 1930.

LONDON:
PRINTED FOR THE LINNEAN SOCIETY OF LONDON,
BURLINGTON HOUSE, PICCADILLY, W.1.
BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

THE LINNEAN SOCIETY OF LONDON.

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1929–30.

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1931.

THE LINNEAN SOCIETY OF LONDON.

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HIS MOST EXCELLENT MAJESTY THE KING,
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PUBLICATIONS: From June 1929–May 1930.

Journal, Botany.

Vol. XLVIII. No. 322.

„ 323.

Journal, Zoology.

Vol. XXXVI. No. 250.

Proceedings, 141st Session, January 1930.

List of The Linnean Society of London, Nov. 1929.

PROCEEDINGS

OF

THE LINNEAN SOCIETY OF LONDON.

(ONE HUNDRED AND FORTY-SECOND SESSION, 1929–1930.)

GENERAL MEETINGS.

7TH NOVEMBER, 1929.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the Anniversary Meeting, held on Friday, the 24th May, 1929, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the 24th May, 1929, was read and laid on the table.

The following Fellows signed the obligation in the Book of the Charter and Bye-Laws and were admitted:—Kenneth Thomas St. George Cartwright, Benjamin Bunting, Percy George Netley, Edgar Barton Worthington, and Francis Gayner.

Certificates of recommendation of the following Candidates for Fellowship were read:—For the second time in favour of Robert Brian Dawson, George Redington, James Herbert Orton, and Joseph Thomas Cunningham. For the first time in favour of Eustace Rolfe Gunther, Sir Oscar Emanuel Warburg, Thomas Henry Parsons, Christopher Allan Hector Perera Jayawardana, John Stephenson, Mohammad Sharif, Herbert William Cousins, Geoffrey Alton Craig Herklots, James Wyllie Gregor, and Lalit Prasad Khanna.

The following proposed alterations in the Bye-Laws were read for the first time:—

CHAPTER I.

Of the Election and Admission of Fellows.

Sect. VI. The words "in the United Kingdom" to be added after the word "Fellow" in the fourth line of first paragraph in Section VI.

The following to be substituted for the second paragraph in Section VI.:—

> "The Council shall decide as to the Number of Ballots to take place at a Meeting, having regard to the Number of Vacancies at the time, and the Council shall select from the Recommendations the Candidates whose Names shall be offered for Election at that Meeting."

Sect. X. Bye-Law, Chapter I, Section X, to be repealed to the words "Annual Contributions," and the following to be substituted for the part repealed:—

> "No Person elected a Fellow of the Society shall be entitled to exercise any Privilege as such, nor shall he be admitted nor his Name entered in the List of the Society until he shall have paid his Admission Fee if any and the Contribution for the current Year and signed the usual Obligation for the Payment of Annual Contributions, and unless he pay his Admission Fee if any and the Contribution for the current Year and sign the Obligation within two calendar Months or within such further Time as the Council may grant, the Election of such Fellow shall be void."

CHAPTER IV.

Of the Foreign Members.

Sections I to IV inclusive to be repealed and the following to be substituted for them:—

> "I. The Number of Foreign Members shall not exceed Fifty. The Election of Foreign Members shall be by Ballot and the Date of such Ballot shall be fixed by the Council.
>
> "II. Any Fellow of the Society may propose a Person for Election as Foreign Member by a Certificate signed by himself and other Fellows. Such Certificate, on the Form provided for that Purpose, shall state the Name and Nationality of the Person proposed and indicate clearly the Grounds on which his Selection is urged. The Certificate shall be given to the Assistant Secretary.
>
> "III. The Certificates proposing Foreign Members shall be filed by the Assistant Secretary, and in the Event of a Vacancy or Vacancies in the List of Foreign Members the

Council shall select from the Persons so proposed at such Time or Times as they may think fit the Number necessary to fill the Vacancy or Vacancies, and the Names of the Candidates so selected shall be read at three General Meetings and the Ballot shall take place at the Meeting at which the Certificate is read the third time.

"IV. No Person shall be declared to be elected a Foreign Member who has not received the Votes of two-thirds of the Fellows balloting."

CHAPTER V.

Of the Associates.

Sections I to III inclusive to be repealed and the following to be substituted for them :—

"I. The Number of Associates shall not exceed twenty-five. The Election of Associates shall be by Ballot, and the Date of such Ballot shall be fixed by the Council. Associates must be elected from Persons who for any Reason are not in a Position to offer themselves as Candidates for Election as Fellows, but whose Work as Naturalists deserves honourable Recognition, and who are likely by Attendance at its Meetings, or by the Communication of scientific Notices, to benefit the Society.

"II. Any Fellow of the Society may propose a Person for Election as Associate by a Certificate signed by himself and other Fellows. Such Certificate, on the Form provided for that Purpose, shall state the Name of the Person proposed and indicate clearly the Grounds on which his Selection is urged. The Certificate shall be given to the Assistant Secretary.

"III. The Certificates proposing Associates shall be filed by the Assistant Secretary, and, in the event of a Vacancy or Vacancies in the List of Associates, the Council shall select from the Persons so proposed at such Time or Times as they may think fit the Number necessary to fill the Vacancy or Vacancies, and the Names of the Candidates so selected shall be read at three General Meetings, and the Ballot shall take place at the Meeting at which the Certificate is read the third Time.

"IV. No Person shall be declared to be elected an Associate who has not received the Votes of two-thirds of the Fellows balloting."

The Sections of Chapter V, at present numbered IV, V, VI, and VII, to be numbered respectively V, VI, VII, and VIII.

CHAPTER XIII.

Of the General or Ordinary Meetings of the Society.

In Section I for "November" read "October."

The following to be added to Sect. III:—

> "Strangers may be officially invited to attend the General Meetings by the President or Officers, but may attend the Anniversary Meeting only on the Invitation of the President."

Dr. A. B. Rendle showed, on behalf of Dr. Maurice Gepp, an abnormal flower of *Tropæolum speciosum* Poepp. & Endl., exhibiting an unusual type of median proliferation. From the centre of the ovary protruded a vegetative shoot about three inches long, bearing numerous small leaves resembling those of the normal plant. This is not a case of vivipary, but a growth of the floral axis continued vegetatively above the pistil. Dr. Gepp stated that the plant, which he had grown for three years, had never produced a normal fruit.

Dr. D. H. Scott exhibited, and gave an account, illustrated with lantern-slides, of some Fossil Seeds of *Eospermatopteris*, the oldest known Spermophyte.

The seeds of *Eospermatopteris* exhibited are of Upper Devonian age, and are attributed to the great "Tree-ferns" forming the Fossil Forest of Gilboa, in the State of New York. The seeds are from 6 to 8 mm. in length by about 3 mm. in breadth; they are borne on forked stalks. Each seed has a pointed, presumably micropylar, free end. The bodies have all the appearance of seeds, but the internal structure is not known.

The "Tree-ferns" were originally described by Sir William Dawson. They, and the seeds attributed to them, have been fully investigated by Miss Winifred Goldring, of Albany.

The specimens exhibited were kindly lent by Dr. Kräusel, of Frankfort, who obtained them on a visit to the American locality.

Dr. A. B. Rendle agreed that the bodies exhibited showed no features inconsistent with their being true seeds.

The President expressed the Society's appreciation of the interest and importance of Dr. D. H. Scott's exhibit.

Dr. Hugh Scott gave a lecture, illustrated with lantern-slides, of a natural history excursion into Basutoland.

This excursion, made in February 1929, during a holiday in South Africa, occupied only about eleven days. It was undertaken to see the general conditions in a little-visited part of South Africa, to collect as many insects as possible, and to compare this very mountainous country with other mountain regions where the lecturer's field-work has lain. Basutoland is nearly 150 miles across in either direction. It lies at the principal watershed of South Africa. From its mountains the Orange and its tributary, the Caledon, flow hundreds of miles W. to the Atlantic, while numerous shorter rivers run down S.E. to the Indian Ocean. Along the N.W. side lies the Maluti range, rising at its W. end

to about 10,000 feet in Mt. Machacha. The S.E. frontier is formed by part of the Drakensberg, and the area between the two ranges is filled with lofty mountains and deep valleys. There are no railways except a mile or two linking up Maseru, the capital, on the N.W. frontier, with the South-African system. The few roads are all in the less rugged W. borders, the rest of the country being penetrated only by bridle-paths.

Until little over a century ago, Basutoland was inhabited almost solely by Bushmen. The foundation of the present Bantu nation, the Basuto, by Moshesh in 1831, and their vigour and progressiveness, have profoundly affected the natural history. Deforestation and destruction of big game have been extensive. Almost the only native "timber" seen was scrub composed of a Rosaceous bush, *Leucosidea sericea*, about 5–15 feet high. All arable land is devoted to cultivation of mealies (maize) and kafir corn (*Sorghum*), and the grassy slopes are stocked with horses and cattle. Entomological collecting resolves itself largely into "sweeping" grass and flowers, searching under stones and working the low dense bush of kloofs. The country would doubtless repay prolonged investigation, which might reveal how far the insects of the mountains differ from those of the high veld surrounding Basutoland, and of the Cape Province mountains a long way south-west.

Basutoland is a native reserve, but with the help of the Local Commissioner at Maseru and other friends an excursion was made over 30 miles E. from Maseru to a branch store at Nyakoesuba, whence the Maluti Mts. were visited. Afterwards the extreme N.E. corner was touched; a three-days' journey by horse was made from Witzieshoek, O.F.S., to the Drakensberg National Park in Natal, Basutoland being re-entered on the summit of Mont-aux-Sources, the highest mountain in South Africa, over 11,000 feet. On top is a flat moorland ending in a precipice more than 2000 feet high, over which the Tugela River falls. Heavy rainstorms and high wind interfered with collecting on the summit, but the broken weather was compensated for by the profusion of flowers in blossom during the summer rains.

The lantern-slides were chosen to illustrate topography, vegetation and the inhabitants. The insects obtained, about 1000 specimens, are being dealt with at the British Museum. A species of cockroach was observed to display maternal care for its young, a fact of considerable biological interest.

Dr. A. B. Rendle asked as to the nature of the undergrowth in the Drakensberg Forest. The forests in the George and Knysna districts recently visited by him, though containing numerous species of trees, were generally poor in undergrowth, thus contrasting with the well-developed undergrowth in the forest on Mt. Kenya.

Mr. H. N. Dixon hoped that Dr. Scott had collected for their insect-contents some specimens of mosses from the Mont-aux-Sources; if so, he would be very grateful to receive the remains

when the insects were extracted, as the mosses on isolated mountain peaks are little known and of great interest.

Dr. Hugh Scott replied that there was little undergrowth in the forests which he saw in the Drakensberg National Park, except a beautiful carpet of orange begonias. Unfortunately, he had gathered no mountain mosses, as he would certainly have done if he had heard Mr. Dixon beforehand.

The President read a letter from Dr. Joseph Pearson, Director of the Colombo Museum, requesting the opinion of the Society as to the advisability or otherwise of the proposed acclimatization of Black Buck (*Antilope cervicapra*) in Ceylon.

After a preliminary discussion of the question by Dr. W. T. Calman, Mr. H. N. Ridley, Mr. F. H. Lancum, and Lt.-Col. J. H. Tull Walsh, Dr. W. T. Calman gave notice that at the next General Meeting he will propose the following resolution :—

> "That this Meeting deprecates all attempts to introduce or acclimatise wild animals or plants in countries where they are not native, unless such introduction is urgently needed for economic reasons, and until a thorough study has been made of the local conditions and of the results that are likely to follow."

In the absence of the author, through ill-health, a paper by Professor G. E. Nicholls, illustrated with lantern-slides, on "A new Syncaridan from the West Coast of Tasmania," was given by Dr. W. T. Calman.

The small freshwater crustacean which forms the subject of this paper was first taken by the author in February 1928 in a *Sphagnum*-choked ditch near Queenstown. As but a few specimens were secured, none of which appeared to be mature, a second collecting trip was made a year later, and resulted in the discovery of the animal in several widely separated localities living under quite diverse conditions.

The third member of the sub-order Anaspidacea to be discovered in Tasmania, it seems most closely related to *Koonunga cursor*, a species at present known only from the Australian mainland. From *Koonunga*, however, it differs in the relative shortness of its peræon and the reduction in the number of its gills, as well as in the loss of eyes. In the male other differences are to be noted, the remarkable antennary sense organ of *Koonunga* being wanting, and the first pleopod is modified more profoundly than in any other Syncaridan.

Less than one-third of an inch in length, colourless and almost transparent, the living animal may nevertheless be distinguished immediately in a mixed assemblage of small Crustacea by its swift and steady gliding movement. The fully mature animal is rendered much more conspicuous by its golden or orange coloured gonads, and in these specimens a chocolate-brown pigment is developed irregularly upon the dorsal surface.

In its eyeless condition, its transparency, its small size, and it cylindriform body, as well as in the reduced number of its gills, i approaches more nearly to the condition seen in the Bathynellidæ than does any other member of the Anaspidacea, these characters being correlated with the subterranean mode of life.

Dr. Calman mentioned also that Dr. S. M. Manton had just returned from making valuable investigations into the Anaspidacea of Tasmania; and Dr. Bidder alluded to her observations on the visual powers of *Anaspides*.

The President thanked Dr. Calman for his presentation of Professor Nicholls's valuable work on a group which is obviously of very great interest.

21st November, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday, the 7th November, 1929, having been circulated, were taken as read, and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of Eustace Rolfe Gunther, Sir Oscar Emanuel Warburg, Thomas Henry Parsons, Christopher Allan Hector Perera Jayawardana, John Stephenson, Mohammad Sharif, Herbert William Cousins, Geoffrey Alton Craig Herklots, James Wyllie Gregor, and Lalit Prasad Khanna. For the first time in favour of Frère Marie-Victorin, Charles Leonard Huskins, George Fox Wilson, The Marquess of Headfort, Edward Hubert Chater, and Spencer Savage.

The proposed alterations in the Bye-Laws were read for the second time.

Mr. W. C. Worsdell exhibited a dried specimen of a hybrid Poppy. He stated that the plant was discovered in a garden at Ashford, Kent, in July 1929, and cannot be matched with any known species. That it is doubtless a hybrid is supported by the fact that, although capsules are formed, no seeds are produced. The present view is that it is a cross between *Papaver somniferum* and *P. Rhœas*, both of which were abundant in the garden. The plant is intermediate in several ways between those two species, *e. g.* it is sparingly hairy, whereas *P. somniferum* is glabrous and *P. Rhœas* is very hairy.

The foliage is glaucous, but is more deeply cut than is usual with *P. somniferum*. The peduncle bears appressed hairs, as in some varieties of *P. Rhœas*. The flower is scarlet, as in *P. Rhœas*. The influence of this last species is also shown by the overlapping lobes of the stigma, whereas those of *P. somniferum* do not overlap. The appearance of the plant when growing was that of an Opium Poppy bearing scarlet flowers; this colour is unknown in this species. No published description of such a hybrid has been seen, but only the bare statement in Fedde's Monograph in Engler's 'Pflanzenreich' that such have been artificially produced.

Professor R. R. Gates and Mr. C. E. Salmon made comments on the exhibit.

In the absence of Col. M. J. Godfery, his paper on "The Pollination of *Cephalanthera*" was explained by Professor E. B. Poulton. Some paintings by Mrs. Godfery and specimens of the insect-visitors were exhibited. The following is the author's abstract of this paper:—

On 16th June, 1921, I read a paper on the Fertilization of *Cephalanthera*. There is no rostellum in this genus, and the various mechanical devices for attaching the pollinia or pollen-masses to visiting insects, which form the outstanding characteristic of the Orchidaceæ and are found in no other Order, are completely absent.

It was shown that a camel's-hair brush, inserted into the flower, becomes smeared on withdrawal with the adhesive matter covering the stigma, and by means of this picks up and withdraws the crescent-shaped pollinia by their convex centres, which protrude slightly from the face of the anther. It was suggested that an insect withdrawing backwards from the tubular flower would similarly smear itself with adhesive matter from the stigma, and emerge with the two pollinia attached by their centres, their ends pointing outwards. I had then never witnessed the removal of pollinia from any of the three British species, though I had once seen *Bombus lucorum* visit the flowers of *C. grandiflora*, but without removing any pollinia.

After hours of watching cut flowers on many days in successive years, I have now had the good fortune to witness the actual visits of the insects which pollinate the three species, and found that the pollinia are attached, not to the head, as I expected, but to the thorax. But my previous suggestion made that the pollinia would be found adhering by their convex centres proved to be correct, except that the point of attachment is a little below the centre, so that one end projects further forward than would otherwise be the case.

The first species I saw visited was *C. rubra*. On 11th June, 1922, my wife was carrying some spikes of this orchid in her hand near Challes-les-Eaux, France, when an orange-red bumble

bee, *Bombus agrorum* F., came to the flowers and entered three. A few days later a similar bee singled out *C. rubra* from a mixed bunch of orchids on my window-sill, and was captured while inside the third flower visited.

At Trient, Switzerland, on the 18th and 19th July, 1929, I took three bees inside the flowers of *C. rubra*, later identified at the Paris Museum of Natural History as *Heriades rapunculi* L. ♂ (= *H. nigricornis*) 2 specimens, and *Andrena* species ♂. They bore no pollinia, but these had been already withdrawn before the flowers were gathered.

C. ensifolia.—On the 20th May, 1929, my wife saw a small greyish insect emerge from a flower of this species with tiny white pollinia on its thorax. Next day, together with Colonel G. H. Evans, F.L.S., we watched some cut spikes at Challes-les-Eaux. We saw several small insects enter the flowers, and at last took one with pollinia on its thorax. On 23rd May we caught another insect similarly adorned, and saw yet another fly off with pollinia. Next day we took three more carrying off pollinia, kindly identified by Messrs. Bénoist and Berland, of the Paris Museum, as *Halictus smeathmanellus* K. ♀. A still smaller insect, also caught bearing pollinia, was identified as *Halictus politus* Schenck ♀.

I nearly missed my opportunity of taking these Hymenoptera through thinking them much too small to remove pollinia from such comparatively large flowers as those of *C. ensifolia*. Having seen *C. grandiflora* and *C. rubra* visited by bumble bees, I expected insects of about the same size to visit *C. ensifolia*. It was a surprise to see it pollinated by such small insects, which did not look big enough to touch the stigma when standing on the lip. There are, however, three to five raised longitudinal crests on the lip, by crawling along the summit of which even the very small *Halictus politus* was able to withdraw the pollinia. These little bees took no notice of the flowers of *C. grandiflora*, but confined themselves entirely to *C. ensifolia*.

C. grandiflora.—On 21st May, 1929, at Challes-les-Eaux, I several times saw a bee of moderate size enter a flower of this species, and after I left, Colonel Evans saw similar bees come to the flowers eight times, and eventually took one, but without pollinia. Next day he saw three similar bees arrive, of which one alighted. It paid no attention to the open lower flowers, which were faded, but leisurely inspected three closed flowers, as if intent on finding a way in. Soon after, another bee examining a spike, appeared eager to find an entrance to a flower. Later, four or five came flying round, but did not settle. Returning after lunch, Colonel Evans saw a bee emerging from a flower, but failed to take it. On 23rd May a number of these bees came to *C. grandiflora*, but no flowers were open. I watched them fly from twig to twig of the bushes alongside as if waiting for the flowers to open, and one or two sought an entrance to the top

flowers. I did not try to take any unless I could see the pollinia, but they left the flowers so rapidly that I never succeeded in capturing one bearing pollinia. There could be no doubt, however, that these bees, identified at the Paris Museum as *Andrena flora* F. ♀, were strongly attracted by the flowers of *C. grandiflora*, and we all felt sure that they were the normal pollinating agents of that species. The absence of further specimens of the plant put an end to our observations. The bees took no notice of *C. ensifolia*, or of any of the other orchids exposed. I saw *Halictus malachurus* K., f. *longulus* Sm. enter a flower of *C. grandiflora*, and took it on emerging with the four parallel pollinia, or rather half pollinia, on its thorax.

As referred to above, I saw *C. grandiflora* visited by *Bombus lucorum* on 7th June, 1919, in Surrey. I have never since seen any *Bombus* go to its flowers. Although this species is so constantly self-fertilized, both in Britain and abroad, the above observations showed that if freshly-opened flowers are exposed where *Andrena florea* is frequent, these insects come freely, even eagerly, to visit them. Only one specimen of *Halictus malachurus* was seen visiting the flowers.

Mr. C. E. Salmon and Dr. A. B. Rendle commented upon the paper.

Professor E. B. Poulton gave an account, illustrated with lantern-slides, of some "Recent observations on Snake-like Caterpillars which throw light on a statement in H. W. Bates's classical paper on Mimicry."

He said that it was a great satisfaction to be able to show upon the screen a caterpillar of the same kind, and very probably of the same species, as the one referred to by Henry Walter Bates in our 'Transactions' of nearly seventy years ago (vol. xxiii, p. 509, 1862). Bates here describes "a very large Caterpillar which stretched itself from amidst the foliage of a tree," and startled him "by its resemblance to a small Snake," and a poisonous one, as "proved by the imitation of keeled scales on the crown, which was produced by the recumbent feet, as the Caterpillar threw itself backwards." This description has always been a puzzle to naturalists, for the Rev. Joseph Greene's suggestion that the larva was a Notodont has never been considered probable, while the known snake-like Sphingid larvæ bore eye-like marks on their dorsal or lateral surfaces, never on the ventral. The mystery has, however, now been solved for us by the Rev. A. Miles Moss, who has made a special study of the life-histories of Amazonian Lepidoptera, and by Lord Rothschild, who has reproduced the beautiful coloured drawings in 'Novitates Zoologicæ.' It is evident, from the descriptions and plates (vol. xxvii, 1920, pp. 391, 392, pl. ix & x), that Bates was referring to a Sphingid larva which deceived him by the reduction of the caudal horn to a mere hump in the final stage, although, as the author has shown,

possessing it fully developed when young. The two larvæ figured on these plates, *Leucorhampha triptolemus* Cram. and *L. ornatus* Rothsch., behave exactly as Bates described, and bear their terrifying eye-like marks on the ventral surface. There can be no reasonable doubt that Bates was describing one of these species or an allied species of the same genus. Prof. Poulton also showed lantern-slides of two South American Lantern-flies (*Laternaria*) which have developed a cephalic process resembling the head of an alligator, and in one species when looked at from above a likeness to the frog *Ceratophrys*.

Mr. H. N. Ridley described a snake-like caterpillar in the Malay States resembling a young viper. The adult viper is brown, but the caterpillars are green like the young vipers, which they approach in size.

Mr. J. T. Cunningham could not see how the markings on a Lantern-fly two inches long could make it resemble a caiman fourteen feet long.

Prof. Poulton replied that in the first place the discrepancy in size was not so very great between the heads of these large Homopterous insects and those of young alligators, whose needle-like teeth give a sharp bite from the moment when they are hatched. Secondly, it had been shown that, where animals have a type-image impressed on their memory, as the occasion of either fear or love, it is the form and colour, and not the absolute size, which produces the impression. The image on the retina of the smaller object near the eye is of the same size as that of a larger object further away.

The President commented on the interest of the exhibition, and, on his invitation, cordial thanks were given to Prof. Poulton.

Dr. W. T. Calman moved his resolution:—

> "That this Meeting deprecates all attempts to introduce or acclimatise wild animals or plants in countries where they are not native, unless such introduction is urgently needed for economic reasons, and until a thorough study has been made of the local conditions and of the results that are likely to follow."

He stated that he intended to make only a few general remarks on the matter, and that those who followed him in the discussion would no doubt give specific instances of serious results that have followed the introduction of animals and plants. This century, and particularly the last few years, has seen a remarkable increase in the appreciation of the damage that is being done to the wild life of the world by the actions of man, and a no less remarkable increase in the sense of our responsibility for handing on to our successors, as little impaired as possible, all the variety and wonder of the living world. Much is being done in many

countries towards this end by game laws, by the establishment of Nature Reserves, and in other ways.

The object of this resolution is to call attention once more to the danger to the native fauna and flora of ill-considered attempts at acclimatisation. We all realize nowadays what Darwin was one of the first to make clear, that the living inhabitants, plant and animal, of any region form an organic whole, united by the most complex links of inter-relationship, and that the disturbance of any one of these links may have far-reaching and incalculable effects.

Some introductions are necessary if the white races are to occupy the empty spaces of the world; some are regrettable but perhaps unavoidable accidents. All that this resolution seeks is to protest against intentional introductions for trivial reasons—for example, for purposes of sport.

Mr. M. A. C. Hinton seconded the motion. He called attention to the risk of a probable introduction of North American Musk-Rats (*Ondatra zibethica*) to Britain in the near future. In 1905 two or three pairs were liberated in Bohemia, and their progeny have now spread over most of that part of Central Europe lying between 47° and 52° N. latitude and 10° and 18° E. longitude. In 1926 the Musk-Rat population of Central Europe was estimated to be 100,000,000. It was impossible to make such an introduction without doing great biological damage. It was true that certain landowners and fur-merchants had made considerable profit from the introduction; but much material damage had been done to embankments by the Musk-Rats, and the burdens of repair and Musk-Rat control were thrown upon the community. An extensive literature relating to the Musk-Rat in Europe now exists; a comprehensive and up-to-date summary has been published by Toldt (Die Pelztierzucht, iv, 1928, pp. 195–200, 219–223, 245–248; v, 1929, pp. 1–11, 31–33, 47–51, 69–73, and 93–97).

The President said that the spirit and intention of Dr. Calman's motion commanded his cordial sympathy and agreement, but the wording seemed too sweeping. Passed in its present form, the resolution would represent the meeting as deprecating the introduction of any of the exotic flowers which adorn our gardens, and yet are certainly not "urgently needed for economic reasons." He thought that the sentiment of the resolution was better expressed in the following words, which he moved as an amendment:—

> "That, in view of the disastrous results which in certain well-known cases have followed from the introduction of animals or plants into countries where they are not native, this meeting is of opinion that acclimatisation should not be attempted without adequate motives and after careful consideration of the possible results of the experiment."

Dr. Rendle said that, while sympathising with the spirit of Dr. Calman's resolution, he agreed with the President that it was

impracticable in its present form, as it would prevent the introduction of plants for horticultural or sylvicultural purposes. He would prefer the resolution as amended by the President. It might be useful to test the resolution by its application to specific cases. A number of well-meaning plant-lovers had recently proposed to introduce plants into suitable wild situations in Great Britain with a view to the improvement or beautifying of the native flora. No true botanist could approve of this, and Dr. Calman's resolution would meet this case. But other cases were not so simple. The introduction of the "Port Jackson Willow," an Australian species of *Acacia* (*A. saligna*), into the Cape Flats, which stretch for twenty miles between Table Mountain and the Hottentot's Holland range, had, we were given to understand, exercised an ameliorating effect on the soil. What had been barren scrub-land was being converted into farm-land as the *Acacia* spread and became dominant. Here was presented a conflict between the natural history and economic points of view. The botanist, ornithologist, and entomologist had to regret the destruction of interesting species coincident with the improvement of the area for agriculture. This might be quoted in the terms of the resolution as "urgent need for economic purposes," but the results of the introduction could not definitely have been foretold.

The classic case of the Island of St. Helena was an instance of the practically complete destruction of one of the most interesting and peculiar insular floras on the face of the globe by the introduction of goats at the time of the discovery of the island in 1501, and later, under the rule of the Hon. East India Company, of trees, shrubs, and herbs from many parts of the world. The latter was a well-meaning attempt to make good the havoc caused by the goats (introduced originally as an act of mercy, that shipwrecked mariners might find milk and meat for their use) and the extravagance of early settlers, but the disastrous effects on the native vegetation could scarcely have been foretold.

Settlers from Great Britain in overseas parts of the Empire were in the habit of introducing plants from the old country into their gardens. In ninety-nine cases these did not spread to the hurt of the native vegetation, but in the hundredth the plant might become a pest, like the Scotchman's thistle in New Zealand or the prickly pear in Australia. Special reference was made to the English gorse which the speaker had seen spreading over the cliffs round the harbour at Wellington and displacing the native vegetation, and, more recently, at St. Helena, strangling one of the few remaining examples of an endemic arborescent Composite on the highest ridges of the island. Numerous similar instances might be quoted. It would seem impossible to foretell the results of the introduction of a given species, and on the other hand impracticable to forbid the introduction generally of exotics into gardens.

Some of the worst pests were accidental introductions, brought in with fodder, wool, &c., but these were presumably outside the

range of the resolution. The resolution in its present form would be extremely difficult of application in the case of plants.

Dr. G. P. Bidder pointed out to Dr. Calman that his resolution was of such wide philosophic interest that in discussing it the critical powers of the meeting would be alert to prove exceptions to its generalities, in complete forgetfulness that we are asked by a Fellow to advise him as to a concrete problem. The whole meeting, and probably the whole Society, was unanimous in disapproving of the introduction of the Black Buck into Ceylon for the greater amusement of sportsmen, unless after the most careful appreciation of the likelihood that an Indian antelope, among the weaker fauna of Ceylon, might increase abnormally and destroy crops and forests. He hoped that Dr. Calman would allow of the expression of this unanimity by adopting the President's form of words.

Lieut.-Col. J. H. Tull Walsh agreed with the reasoning of the Zoological Secretary.

Major S. S. Flower wished no word changed in Dr. Calman's resolution. The Little Owl and the Grey Squirrel are flagrant instances of the harm wrought by irresponsible acclimatisation. Recently he had communicated to the Zoological Society the occurrence of the Fat Dormouse (*Glis glis*) in Hertfordshire and elsewhere. Lord Rothschild had now told him these are descendants of specimens turned out by him. They give an instance of the unexpected changes in an animal acclimatised to a new environment; the Fat Dormouse in England has largely abandoned the practice of winter hibernation, finding that hothouses and other human buildings allow the winter to be passed in activity.

Dr. Calman stated that he was quite unrepentant and saw no reason to diminish his resolution in any way.

Mr. H. N. Dixon suggested that the criticisms would lose force if Dr. Calman would substitute the word "naturalise" for "acclimatise." He would suggest the same change in the President's amendment.

The President was unable to see the distinction drawn by Mr. Dixon.

On the invitation of the President, Mr. N. B. Kinnear moved the adjournment of the discussion. This was seconded and carried.

Dr. S. K. Montgomery gave an account, illustrated with lantern-slides, of his paper entitled "Report on the Crustacea Brachyura of the Percy Sladen Trust Expedition to the Abrolhos Islands under the leadership of Professor W. J. Dakin, D.Sc., F.L.S. in 1913; along with other crabs from Western Australia." The following is an abstract of his paper:—

The Crustacea Brachyura of Professor W. J. Dakin's Percy Sladen Trust Expedition to the Abrolhos Islands in 1913 are described. Of 57 species and varieties in the collection, there are 8 species and 4 varieties described as new; and a new genus is suggested to contain one of these, along with *Grapsus inornatus*

(Hess) and *Brachynotus octodentatus* (Milne-Edwards). New light is thrown on the identities of *Plagusia depressa* (Herbst), *Plagusia squamosa* (Herbst), and *Plagusia tuberculata*. The specific identity of *Schizophrys dama* (Herbst) with *Schizophrys aspera* (Milne-Edwards) and of *Actæa affinis* (Dana) with *Chlorodopsis areolata* (Milne-Edwards) is affirmed. The incompleteness of knowledge of the Western Australian fauna is stressed.

The opinion is expressed that the Brachyuran fauna of the Abrolhos Islands is more nearly related to that of the north of Australia than to that of the south and south-west. It is suggested that the Ninety Mile Beach, north of Broome, has divided the Brachyura into a Northern and a North-western group. The relative absence of the Oxystomes both from the North-western and the Southern groups is noted. The Brachyuran fauna of Australia as a whole, and of the South of Australia in particular, is shown to vary considerably from the general homogeneity of the Indo-Pacific.

Dr. W. T. Calman commented upon the paper, not only as a valuable contribution to our knowledge of the Crustacea Brachyura, but also as of interest to zoologists generally from the point of view of geographical distribution. Mr. E. G. Baker added some remarks.

5TH DECEMBER, 1929.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 21st November, 1929, having been circulated, were taken as read, and confirmed with verbal correction on page 3 of the Report of that meeting.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of Frère Marie-Victorin, Charles Leonard Huskins, George Fox Wilson, The Marquess of Headfort, Edward Hubert Chater, and Spencer Savage.

The PRESIDENT having explained the proposed alterations in the Bye-Laws which had been read for the first time on the 7th November, and for the second time on the 21st November, 1929, a ballot was taken. After scrutiny of the votes, and of the signatures of Fellows attending the Meeting, the President announced that the alterations had been passed by the necessary majority.

Dr. Arthur W. Hill exhibited a drawing of the remarkable West Australian subterranean Orchid, an account of which was given by Dr. A. B. Rendle at a meeting of the Society on January 17th, 1929. The drawing of this orchid, *Rhizanthella Gardneri*, was received from the Rev. H. Purefoy FitzGerald, for whom the drawing had been made by Mr. C. A. Gardner, Government Botanist, Department of Agriculture, Western Australia. The Orchid is a saprophyte entirely devoid of chlorophyll.

Mrs. E. S. Grubb (Visitor) gave a lecture, illustrated with lantern-slides, entitled "The Biological Station of Alto da Serra, São Paulo, Brazil."

This Biological Station consists of about 150 acres on the summit of the Serra do Mar, between the town of São Paulo and the sea. Von Ihering, in 1909, when he was Director of the São Paulo Museum, had his attention called to the rich and interesting vegetation, and, obtaining a concession of land, began the organization of the Biological Station, which, however, he was unable to carry on, and sold to the Government. After being under various Directors, in 1923 it again became attached to the Museum. A valuable feature of the area is that it comprises not only mountain forest, but stretches of open marsh-land and grass vegetation, all alike subjected to extreme and continuous humidity.

The chief point about the Station is that no interference is allowed: nothing is taken out and nothing planted, and no clearance beyond cutting paths through the virgin growth to facilitate research and exploration. The pathways, thirteen miles in total length, are named after those who have rendered service to the study of Brazilian botany.

It is the object of the Director both to retain the original vegetation as far as possible and to give what assistance he can in its investigation.

Dr. J. C. Willis complimented Mrs. Grubb on her beautiful lantern-slides. He knew the Station well, as he had been sent by the Brazilian Government to report upon it. Mrs. Grubb's pictures gave a very good impression of its wonderfully rich flora, hardly to be equalled at a similar height above sea-level. He would protest against the mistake of botanists always going to the eastern tropics under the impression that the American tropics had been thoroughly worked; on the contrary, he had rarely gone into the forest without finding an unknown plant.

Mr. T. B. Blow suggested that, as a representation of tropical forests for those who had not seen them, the lantern-slides are somewhat over-coloured.

Mrs. Grubb agreed, and said that her husband had made ust the same criticism.

The President said that he had requested Dr. Willis to speak, as the Fellow most qualified to give a skilled appreciation of the

lecture, but to that appreciation he added the thanks of the meeting for the charming excursion on which Mrs. Grubb had conducted them.

Adjourned Discussion on the Introduction of Alien Species.

The President pointed out that, while the Society was asked for advice as to the introduction of Black Buck into Ceylon, the immediate question before them was that another form of words should be substituted for Dr. Calman's resolution. He called on the President of the Royal Horticultural Society for information as to the manner in which horticulturists would regard the resolution as it stood.

Mr. G. W. E. Loder considered that, taking into account all the risks run and all the damage done, nevertheless the human race has gained immeasurably from the introduction by human agency of plants and animals into countries to which they are not native. Had Dr. Calman's resolution been statutory law in Queen Elizabeth's reign the potato would have been prohibited; at a still earlier time wheat would have been prohibited. He had been asked to speak as representing the Royal Horticultural Society,—in that capacity he could not agree to such a sweeping condemnation of the great collectors who had enriched our gardens and woods. At the last meeting there had been mention of the Musk-Rat.—had the zoological Fellows considered the question of the Silver Fox now being bred for its fur in England?

Mr. J. C. Shenstone referred to the wild-flower garden on a building site at Aldwych, which a few years ago attracted much attention. Unfortunately, some mischievous persons scattered seeds of garden flowers over the site, thus destroying the scientific evidence of the self-sown garden.

Dr. Calman, on the President's invitation, replied that Mr. Loder had misinterpreted the resolution, which would not have prohibited tea, the potato, or wheat. He regretted being unable to accept the form of words moved from the Chair, for he objected to the resolution being based merely on a few disastrous results. He stood by his own wording, which condemned irresponsible acclimatisation even if unaccompanied by flagrant disaster, and in this he thought would have the agreement of every Fellow of the Society, even the President of the Royal Horticultural Society.

The President considered that the wording he proposed would command more universal assent, and put his amendment to the meeting.

The amendment was lost.

Mr. N. B. Kinnear proposed an amendment that for the words "introduce or acclimatise" be substituted the words "introduce and naturalise."

Mr. A. J. Wilmott seconded the amendment.

The amendment was carried.

Mr. W. G. Freeman said that, having spent many years in Colonial Departments of Agriculture, he naturally looked at the motion from the point of view of an officer concerned with the introduction of desirable animals and plants and the prevention of the importation of those which are undesirable. Whilst agreeing entirely with the general idea underlying the resolution, he was unable to agree with its terms. There were many plants, for example, which it would be desirable and useful to import into a country, but for which no claim could be substantiated that they were urgently needed for economic reasons.

It had been suggested by some previous speakers that, whilst it might be permissible to import certain plants or animals, attempts should not be made to naturalise or acclimatise them. He did not think that any such distinction was practicable, as there were well-known instances of animals and plants which no one had deliberately attempted to acclimatise or naturalise, but which had found conditions suitable to them and "got away" and become nuisances. Agricultural officers in the Colonies did not lightly embark on introductions, but at present the weak point was that in many countries there was no law by which, say, a private person could be prevented from making an introduction which might be regarded as undesirable. There were laws and regulations controlling the importation of plants and animals which might carry diseases or pests, and the necessary machinery for their enforcement. To secure an advance on the present position, there should be laws on similar lines controlling the importation of all animals and plants, giving power to prohibit entirely or to permit importation under certain conditions.

Such laws were, he believed, already in existence in the U.S.A., South Africa, and some of the Australian States. As a concrete example Mr. Freeman instanced a New Zealand Act of 1895, which provided that "No Society, authority, or person shall introduce or import into the Colony, or turn at large for the purposes of sport or acclimatisation, or as game, any wild animal or bird whatever, without the consent in writing of the Minister for the time being in charge of the Department of Agriculture; nor shall any insect or reptile be introduced or imported into the Colony without such consent as aforesaid."

To give similar powers to control plant importations, there was the New Zealand "Introduction of Plants Act," 1927, No. 39. This provides machinery for controlling the importation of plants of a kind not hitherto found in New Zealand. The importation of certain other plants, namely those classified as noxious weeds, is definitely prohibited.

In order to bring matters to a practical issue, he would suggest as an amendment that the resolution be worded as follows:—

"That this meeting recommends that the Government of each country of the British Empire should consider the advisability of taking any action necessary to prohibit entirely, or to permit, subject to any conditions which may be deemed advisable, the

importation of any animals or plants not hitherto found in their territory; such prohibition or permission to be determined on in each case after giving careful consideration to local conditions and the results that are likely to follow."

Should a resolution on these lines meet with the approval of the Society, he suggested that it should be sent to the Secretary of State for the Colonies and Dominion Affairs with the request that it be submitted to the Governments concerned for consideration.

Prof. R. R. Gates seconded Mr. Freeman's motion, and said that he thought the proposal to send a copy of this resolution to the Colonial Office was a very reasonable and useful action, which the Linnean Society might take.

Mr. A. J. Wilmott said that Mr. Freeman's suggestion raised considerably wider issues which would require much consideration. He thought it preferable that the Linnean Society should keep to its own particular sphere, which is the study of wild life, which study is often made more difficult or impossible owing to the interference caused by those who deliberately try to naturalise alien animals or plants. This is quite different from introducing plants into gardens or for economic reasons; such introductions rarely affect the natural vegetation. Naturalisation must upset the balance of nature. The study of wild life becomes increasingly difficult with the continual restriction of its area, and such areas as remain to us should be kept as free from interference as possible.

Dr. A. W. Hill said he would support Mr. Freeman, for unless some such action as he suggested were taken no good result could be looked for from the discussion.

Mr. J. Ramsbottom suggested that Mr. Freeman's amendment was too wide-sweeping to be pressed at such a meeting. The matter of the Black Buck was fairly simple; but if it were pointed out that some of the regulations mentioned by Mr. Freeman were essentially quarantine regulations for the prevention of the introduction of such plant diseases as chestnut blight and white pine blister rust, it would be seen that we got a complex of host, parasite, and politics. It was much better to restrict discussion to Dr. Calman's motion.

The President ruled that Mr. Freeman's motion was not an Amendment, but a proposal to substitute another subject for that on the Agenda.

Dr. G. P. Bidder begged that the discussion should be continued by Fellows who knew the tropics, and that they should illustrate Dr. Calman's general thesis by particular instances, related to the proposed introduction of Black Buck into Ceylon. The Game Protection Society, who wished to introduce Black Buck into Ceylon, presumably know of plains there suitable to its life, and they may rely on panthers and sportsmen to prevent its disproportionate increase. But to the mere reader of text-books it appeared possible that the Buck, which maintained its numbers

in Orissa where there were not only panthers, but tigers, wolves, and dhole dogs, might increase in its new home to a noxious extent.

Mr. A. H. Maude agreed that the discussion should properly be centred on the question of Black Buck, but he considered that the general terms of Dr. Calman's motion might be misconstrued as condemning the work of acclimatisation societies, which was well-considered and had often been highly beneficial. Their experiments in gardens under skilled observation afford the true safeguard against the introduction of harmful plants.

Mr. F. H. Lancum suggested that the country concerned could not afford to take the risk of introducing the Black Buck. Past experience has shown that in the majority of cases where alien fauna are introduced one of two results follows,—either the species concerned dies out, or it flourishes too well, generally at the expense of some native species. He cited as instances the rabbit in Australia, the mongoose in Jamaica, the English Sparrow in America, the Musk-Rat in Central Europe, and the Little Owl and Grey Squirrel in this country.

Mr. W. P. Pycraft was of opinion that if an animal were introduced into a new environment, it would be impossible to foretell how far the native fauna and flora would be affected.

Mr. H. N. Ridley said that he had not seen any place in Ceylon suitable for Black Buck, unless possibly Horton Park. Although he considered that the introduction would be perfectly harmless, nevertheless he thought it would be a failure. He pointed out that Tiger and Black Buck do not inhabit the same ground.

Mr. I. H. Burkill remarked, with regard to Mr. Freeman's proposal, that it was obvious from the fact that Dr. Pearson had advised the Government of Ceylon not to permit the importation of the Black Buck, that his Government had already legal powers in such matters.

Lt.-Col. J. H. Tull Walsh agreed with Mr. Ridley that there was no place in Ceylon suitable for Black Buck. It was a beast very destructive to crops, less by what it eats than by what it tramples down.

Mr. A. J. Wilmott emphasised the point that naturalised species often change their habits to suit a changed environment, as when rabbits climb trees.

Mr. W. P. Pycraft suggested that if they introduced the Black Buck into Ceylon, they would have to introduce the Tiger as well.

Dr. W. T. Calman moved that his resolution should be communicated to the Colonial Office, with a rider to the effect that the subject was brought to the notice of the Society in connection with the proposed introduction of Black Buck into Ceylon.

The President having put the question to the meeting declared that the motion of Dr. Calman [p. 11], with Mr. Kinnear's amendment [p. 17], and Dr. Calman's rider, was carried unanimously.

19th December, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday, the 5th December, 1929, having been circulated, were taken as read, and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—Anna McClean Bidder and David Raitt Robertson Burt.

Certificates of recommendation of the following candidates for Fellowship were read:—For the first time in favour of Robert Benson Ewbank, C.I.E., Francis Kingdon Ward, and Joseph Calvert.

The following candidates, whose names were read for the third time, were balloted for and elected Fellows:—Ernest Philip Foquett Sutton, M.B.E., Robert Brian Dawson, M.Sc., George Redington, M.Sc., James Herbert Orton, D.Sc., Joseph Thomas Cunningham, M.A., Eustace Rolfe Gunther, M.A., Sir Oscar Emanuel Warburg, O.B.E., M.A., Thomas Henry Parsons, Christopher Allan Hector Perera Jayawardana, M.A., Lt.-Col. John Stephenson, I.M.S. (retd.), D.Sc., Mohammad Sharif, M.Sc., Herbert William Cousins, D.Sc., Geoffrey Alton Craig Herklots, Ph.D., James Wyllie Gregor, Ph.D., Lalit Prasad Khanna, M.Sc., Frère Marie-Victorin, D.Sc., Charles Leonard Huskins, Ph.D., George Fox Wilson, The Marquess of Headfort, Edward Hubert Chater, B.Sc., and Spencer Savage.

The President read the following notice:—

> "By courtesy of the President and Council of the Linnean Society a general meeting of British Botanists will be held at the Society's Rooms, Burlington House, Piccadilly, W. 1, at 3 p.m., the 10th of January, 1930, when the Chairman of the Executive Committee will report the progress made in organising the Fifth International Botanical Congress. All interested in the matter are invited to attend."

Professor Dame Helen Gwynne-Vaughan, G.B.E., gave an account, illustrated with lantern-slides, of her joint paper with

Mrs. H. S. Williamson, entitled "A contribution to the study of nutritive Heterothallism." The following is an abstract of the paper:—

There is evidence that a study of nutritive heterothallism may prove of value in the elucidation of the significance of sex. So far nutritive heterothallism has not been recorded in any species with normal syngamy. In *Humaria granulata*, a coprophilous member of the Discomycetes, nutritive heterothallism is associated with the presence of a functional oogonium.

Blackman and Fraser in 1907 showed that the fruit develops without an antheridium, but that a globular oogonium is present from which ascogenous hyphæ arise. These facts are confirmed. The oogonium is multinucleate from its origin; its nuclei undergo two simultaneous, karyokinetic divisions, and fuse in pairs before passing into the ascogenous hyphæ. The evidence for fusion is confirmed by changes in the number of nuclei. Karyokinesis is simultaneous in all ascogenous hyphæ and in any nuclei remaining in the oogonium from which they arose. Divisions take place independently in each developing ascus, and here reduction is accomplished.

The spores are incapable of germination till five months after they are shed; they remain viable for a year or more. Single-spore cultures produce normal archicarps, but these fail to form ascogenous hyphæ, nor is any sheath developed around them. In about 50 per cent. of cases fruits develop where two monothallic strains meet. The strains are of two kinds, + and −. Since each produces oogonia, it is held that the difference between them cannot be sexual.

Mycelial fusions are common; when they take place between + and − strains, the oogonia in the neighbourhood form ascogenous hyphæ and develop into fruits. Their asci contain both + and − spores, showing that fusion of + and − nuclei takes place. Not only the oogonium and its branches, but the sheath hyphæ developed from the lower cells of the archicarp are affected by the association of + and − strains.

Mrs. H. S. Williamson said she had nothing to add to what the speaker had said. The attempts to obtain synthetic media had been very extended.

Mr. J. Ramsbottom congratulated the investigators on having added important facts to our knowledge of heterothallism, although the amount of recent work makes it difficult to realise the significance of some of the points. Blakeslee's work on Mucoraceæ seemed to indicate that heterothallism is a sex phenomenon, despite the fact that all heterogamous species are apparently homothallic. Since 1918 the problem has widened considerably, and we have hetero-homothallism in several species of *Coprinus*, as mentioned by the lecturer, together with four different strains in the sporophores of some *Coprini* and with geographical races which would require the assumption of innumerable sexes if the sex interpretation is the correct one.

The present investigation, in addition to heterothallism, added several points to the well-known study made by Dame Helen and V. H. Blackman, *e. g.*, the method of nuclear division in the ascogonium; from the fact that two ascogonia-bearing hyphæ fused it might be that here we have the explanation of the fusion of "female" nuclei in pairs in the ascogonium. He asked the speaker whether any attempt was made to influence the growth of strains by adding substances to the dung-extract medium. Also whether the possible effect of other fungi on the growth had been tried, the "mixed culture" frequently involuntarily achieved was one which had possibilities, as Ashby's results showed with *Phytophthora* where the presence of one species induced oospore production in another *Phytophthora*.

Any investigations on heterothallism are of value, for, apart from academic and systematic interest, they should eventually lead to the understanding of many economic problems, such as the incidence of rust-fungi.

Dr. B. F. Barnes stated he had nothing to say except that, working in the same laboratory as the investigators, he had watched the progress of the research with great interest.

The PRESIDENT complimented the lecturer on her clear exposition of experiments as interesting to biologists in general as to mycologists and other botanists. Zoologists have found that the easy expositions formerly current on the nature of sex are no longer possible. In Mollusca—largely through the researches of Dr. Orton, elected a Fellow of the Society at that meeting—it has been found in the oyster and the slipper-limpet that sex alternates, and may alternate again and again in the same individual, from male to female and back again. Even among such high vertebrates as birds the sex had been changed by disease or by operation, notably in experiments by Dr. Crew, of Edinburgh, inducing change of sex in the barn-yard fowl.

In reply, Dame Helen said that the President's remarks were particularly interesting, as indicating that sex was very complex in organisms other than fungi. In answer to questions, she said they had not tried to vary the chemical constitution of a medium of unknown composition, preferring to attempt to obtain growth on a purely synthetic medium. She did not regard the fusion as one between two female mycelia. The mycelial fusion was of monœcious mycelia in a monogamous plant: there was no sex difference, but a physiological difference running parallel to sex.

Dr. G. CLARIDGE DRUCE exhibited and gave an account of some plants new to Britain. The following plants were shown:—*Equisetum occidentale* (Hy) Coste, found in Surrey. In 1912 the speaker found growing out of the gravel in a newly-made path an *Equisetum* which, by section and characters, was referred to *E. hyemale*, a plant already on record for Surrey. It was then thought to be native, and that it had been growing there before the house was built. Lady Davy, who saw it there this year, doubted if it

were identical with the *hyemale* of Weston-super-Mare. A visit was therefore paid to examine it. After seventeen years the plant had much increased, and now not only grows on the path, but has spread into the garden and the adjoining field. Examination shows it to be the *E. hyemale* var. *occidentale*, which the Abbé Hy showed was a common form of *hyemale* in western France. Rouy & Foucaud (Fl. Fr. xiv, 505) also treat it as var. *b* of *hyemale*, but Coste, in 'Flore de France,' makes it a full species, and says it occurs in France "plutôt occidentale et centrale." The botanical characters by which it is distinguished were given.

Hieracium pulmonarioides Vill., from Mells, north Somerset.

Thymus britannicus × *glaber* Ronniger—*T. Lansdowneiæ* Druce, Blackland, Wilts, found in July last, and on Selsey Common, Gloucestershire, in the same month. It is a hitherto undetermined hybrid.

Scutellaria Columnæ All. A native of Italy, Greece, Serbia, etc. Wooded valley near Mells, N. Somerset.

About four specimens were found by the Rt. Hon. H. Baker in July last. Later in the same month we found it by the path, still in flower. Higher up the hill-side it was in great quantity. It is, of course, adventive, as it is in the neighbourhood of Paris, etc.

Alchemilla controversa Buser, from Cave Hill, near Belfast.

Carduus pratensis × *palustris* (= *C. spurium* Delastre), from near S. Moulton, Devon.

Coriandrum tordilioides Boiss., from near Burton-on-Trent.

Also several hybrids of *Rubus* were shown, and a hybrid between the blackberry and the raspberry.

Mr. C. E. Salmon said he had seen the *Equisetum* about eleven years ago, and apparently it was quite a good species. It is probably introduced. There was one definite record for *E. hiemale* in Surrey,—Wanborough Woods, near Guildford, where, seven years ago, there was about half an acre of it, but apparently the plant had disappeared. One advantage of studying the genus *Alchemilla* was that species growing in a garden did not seed about like dandelions.

Mr. E. G. Baker, speaking of segregate *Alchemillæ*, asked Dr. Druce what was meant by *Alchemilla minor* Huds. There were several of Hudson's plants in the Sloane Herbarium, but was there any material of *A. minor* available for identification?

Mr. H. W. Pugsley said some of the new forms were highly critical,—we seemed to be relying more and more on less and less. *Hieracium pulmonarioides* one gets everywhere in one's own garden: he had seen it also on the Cathedral at Arras. It was rather an arrant weed.

Dr. C. L. Huskins asked whether the hybrid between the raspberry and blackberry was fruitful.

Dr. Druce, in reply, said that the hybrid bore fruit, which resembled the raspberry rather than the blackberry. There was no *Alchemilla minor* in the Sloane Herbarium.

Mr. F. Howard Lancum gave a paper, illustrated with lantern-slides, "On the eviction-method of the Cuckoo."

Although the nestling cuckoo's method of eviction is very well known, and has frequently been described, photographs of the process are comparatively scarce; and although the author had photographed the incident many times, it was not until last summer that he secured pictures which clearly illustrated the various stages of the eviction process.

The egg from which this cuckoo hatched was originally laid in the nest of a pied wagtail, which deserted, and was afterwards removed to the nest of a yellow-hammer, where it hatched. Careful note of the time required by other young cuckoos to effect an eviction showed that, on an average, it took three and a half minutes to complete the process. In this case, although the cuckoo ejected the egg many times during the morning, in only one instance did it take longer than twenty seconds to do so.

The first slide showed the cuckoo energetically demanding food, which it did at frequent intervals while being photographed. The second illustrated the beginning of the eviction movement: the cuckoo insinuated a wing underneath the egg and tilted it inward on to its hollowed back. The third slide showed the egg in position, exhibiting the clearly-defined hollow of the bird's back, and made clear the manner in which the egg was held by the bird's wings and backward-tilted head. The fourth slide showed the egg being pushed up the wall of the nest, the cuckoo meanwhile turning its back to it and maintaining a firm grip on the nest-material with its feet. This shows the necessity for the abnormal development of a young cuckoo's feet. The fifth slide showed the beginning of the throwing-out movement, and the cuckoo's action in pushing the egg out backwards with its outspread wings. The sixth slide showed a later stage of the throwing-out movement, when the cuckoo had its wings at almost full stretch, with the egg jammed between its back and the nest-rim.

The seventh slide showed the final push. The speaker explained that, as the slide indicated, this was very vigorous, and the force used was so great that the cuckoo almost followed the egg. It was seen that the bird had lost its hold with one foot, and was clinging tightly to the nest-material with one wing in an effort to regain its balance.

It was a remarkable fact that the cuckoo evicted the same egg (which was replaced on each occasion) fifteen times in an hour. We must be surprised at the strength and persistence of so young a bird (approximately thirty-six hours old), which could with ease repeatedly evict an egg nearly as heavy as itself, climbing an almost perpendicular wall to do so.

Mr. R. H. Burne remarked that the photographs were especially interesting as illustrating the hollow in the young cuckoo's back, and asked what is the framework of the hollow? This was described many years ago, but was always afterwards referred to

as a well-known thing rather than described in detail. What structures form this hollow? Is the skeleton modified temporarily to make this hollow?

The speaker said he did not know the structure of the hollowed back, but believed the hollow to be formed by the soft parts. If one places one's finger on the back of the young bird, the hollow is felt fitting the tip of the finger, and a remarkably strong upward pressure is felt to be exerted in response to the touch of the finger.

The President said that all present had admired Mr. Lancum's photographs of an incident in natural history which had always excited curiosity and wonder. On his invitation the meeting accorded warm thanks to the lecturer.

9TH JANUARY, 1930.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 19th December, 1929, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—John Stephenson, Sir Oscar Emanuel Warburg, and Spencer Savage.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of Robert Benson Ewbank, C.I.E., Francis Kingdon Ward, and Joseph Calvert.

The PRESIDENT read a letter from the Société Linnéenne du Nord de la France asking for subscriptions towards a memorial which is to be erected in the garden of the house where LAMARCK was born. Only a few scattered bricks and blackened stones are left of the house, as it was situated in the war zone, at Bazentin, near Albert. This letter had been discussed by the Council, which had decided that a subscription of five guineas from the Linnean Society would allow the name of the Society to appear in support of the project, while the Assistant Secretary would receive subscriptions from individual members to be forwarded to the Société Linnéenne. The Council would be glad to know

whether this course of action had the approval of the General Meeting.

On a vote being taken the meeting approved unanimously of the subscription from the Society and the opening of a list for individual subscribers.

The PRESIDENT then communicated to the meeting the resolution of Council in regard to Syon House, and read a letter from Dr. A. W. Hill saying:—"You can fully appreciate what a terrible thing it would be if anything were done to spoil the wonderful view of this reach of the Thames, which has remained in its present condition since at least 1770, for we have a record of the view painted by Richard Wilson in 1776, which might almost have been painted a few weeks ago." The President, having called attention to the exhibit of a recent photograph of Syon Reach and a photograph of Richard Wilson's view of the same spot, invited the Meeting to pass a resolution similar to that passed by Council:—

> "The Society views with the utmost concern and regret the reported proposal in regard to the grounds of Syon House,"

and to authorize himself and the Secretaries to express publicly in fitting terms, including this resolution, the disgust which every Fellow must feel at the proposal to utilise Syon Park for a large sewage disposal scheme.

By a show of hands, the Meeting passed unanimously the resolution and the authority.

Mr. W. H. THORPE (Visitor) gave a paper entitled "Further Notes on Biological Races in *Hyponomeuta padella* (Linn.)," of which the following is an abstract:—

It has been shown previously that the small Ermine Moth, *Hyponomeuta padella* (Linn.) [*H. variabilis* Zell., *H. malinella* Zell.] is split into two well-marked biological races, one attached to Apple, the other to Hawthorn, Blackthorn, etc.

Further evidence was now brought forward which suggests that the latter form is itself split into two less strongly marked biological races, one attached to Blackthorn (*Prunus spinosa*) and the other to Hawthorn (*Crataegus Oxyacantha*). The previous conclusion that *H. cognatella* shows no tendency to split up into similar races is confirmed.

The author added that much further investigation is required before we can feel that we know what is the nature of a biological race. In insects specific characters have usually no survival value; it is possible that food preferences produce physiological changes that result in these specific differences. It may be, however, that the question of sex-preference for a mate nurtured on the same leaf proves to be the most important factor.

Miss D. Aubertin stated that certain flies are parasitic on *Hyponomeuta padella*. In one species of fly, it was observed that those bred from *padella* feeding on apple varied slightly from those bred from *padella* feeding on hawthorn. These two forms were considered to be a case of incipient speciation, and a suggestion has been put forward to the effect that the differences are caused by physiological differences in the host caterpillar.

In reply to questions by Professor E. J. Salisbury and Dr. E. J. Collins, the author stated that he had been unable to prove whether the third generation did or did not retain the food-preference of their grandmother—the mortality in the experiment was too great for the figures in regard to survivors to be of value. The eggs are laid in clutches of 10 to 35 eggs, and the number in a clutch appears to be rather larger on the favoured plant.

Mr. J. Ramsbottom said with what pleasure he had listened to a zoological communication which suggested similarities with what is known in a group so remote from moths as the Fungi. Biological species or races were first described in rusts, and modern work shows that numerous strains or physiological forms exist which are confined to certain pure lines of host-plants. Correlated with this specialization of parasitism was the occurrence of numerous strains in saprophytic species which can be distinguished more easily by their effects on certain media than by their microscopic characters.

Dr. W. T. Calman objected altogether to the name "biological species." What are species which are not biological—mineralogical?

The author answered that in entomology the term is necessary. In most cases where the determination of an insect is required its biological characters are not known, and if genera and species were defined by them classification would be thrown into hopeless confusion.

Dr. C. Tate Regan signified his agreement on this point.

Lt.-Col. J. H. Tull Walsh compared the case of bacteria, which are often only known apart by their physiological characters. They are physiological races.

The President, on behalf of the Society, thanked Mr. Thorpe for his very interesting paper, with its highly suggestive observations and questions.

Mr. J. T. Cunningham, F.L.S., read his paper entitled "Adaptive Evolution."* The following is the author's abstract:—

Two recent general reviews of the subject of adaptation in animals entirely omit consideration of (1) Metamorphosis and Recapitulation, (2) Sexual Dimorphism, especially the relation of these phenomena to internal secretions or hormones. Consideration of these subjects is essential to the discussion of animal adaptation.

* See also p. 165.

Metamorphosis.—The larva of the frog or newt breathes by means of gill-slits and gill-arches, which are homologous with those of fishes, and therefore the larval stage represents the ancestral fish. The larva develops into the adult, air-breathing form by the gradual closing of the gill-slits, transformation of the gill-arches, and development of the lungs. There is no evidence of the occurrence of similar changes as mutations independent of the conditions of life. It has not been proved that comparable changes arising as mutations are influenced by secretion of the thyroid gland in the same way as metamorphosis in the tadpole of the frog and in the axolotl. On the Lamarckian theory this influence of thyroid secretion can be explained on the hypothesis that the modifications were produced at a stage when the relative amount of the secretion had increased to a certain degree, and that the inherited tendency to metamorphosis could therefore only show itself in presence of the same relative amount of the hormone. Similar considerations apply to the metamorphosis of flat-fishes.

Sex-limited Characters (*Secondary Sexual Characters, Sexual Dimorphism*).

Darwin pointed out that sexual selection could only produce differences between the sexes by acting on variations which were already sex-limited. It is now known that the limitation in the case of male characters in mammals is due to the fact that normal development of such characters depends on the hormone derived from the testes. Using the term gene in a general sense for the part of the gamete which causes the development of a certain character, it may be stated that the genes of the sex-limited characters are present in females as well as males, their development depending on the sex-hormones, while the genes of sex-linked characters are in one of the sex-chromosomes and are not affected by hormones. The theory put forward by me in 1908 is that the sex-characters, such as antlers in stags, were originally due to external stimuli, such as the blows inflicted by the stags in sex-combat. The reaction to the stimuli consisted of hypertrophy of tissues. These tissues gave out exudations which diffused through the body and acted on the corresponding genes in the gametes. The effect of this was that the genes were modified so as to cause hereditary development of the hypertrophy, but only in the presence of the testis hormone which was present when the modification took place.

The chief general conclusion is that evolutionary changes are of two kinds, namely, those which consist of mutations of internal origin, with no relation to external conditions, and those which have such a relation and can be ascribed to the action of external stimuli.

The author showed a lantern-slide of the bird-of-paradise, to illustrate secondary sexual characters. His view was that the erection by the male of his special plumes in display stimulated

the cellular tissue of the papillæ from which these plumes developed, so that the longer plumes were produced. The hypertrophied papillæ would give off hormones which influenced the gametes within the testes, so that the feathers of subsequent generations were more strongly developed. The spur in *Gallus bankiva*, the ancestor of our domestic fowls, as a weapon in fighting has an adaptive function, but the comb is not merely useless but injurious, and only a benefit to the adversary. Both spur and comb, however, may be regarded as the effect of mechanical stimulation arising from the mode of fighting between the cocks.

The President commented on the very interesting nature of the subjects discussed by Mr. Cunningham. Mr. Pycraft had recently published in 'Science Progress' an article from another point of view; and he invited him to speak on Mr. Cunningham's theses.

Mr. W. P. Pycraft criticised the common supposition that sexual dimorphism is a rule in birds. In many birds male, female, and young have similar plumage. In some the male takes on a gay plumage, and the female and young are alike in dull colouring, as in the house-sparrow. In others the female follows the male, and only the young are plainly clad, while in the tree-sparrow female and young alike have the same gay plumage as the cock. If the author's theory be correct as to birds-of-paradise, why has the love of display in the cock not caused similar feathers to lengthen in the brilliant kingfisher? The wattles of the cassowary cannot be due to bites from the beaks of rival cocks, because the cassowary fights with his toe. Nor can the inflated moustaches and crest of the bell-bird be explained in such a way.

Professor W. Garstang objected to the disproportion of the result to the supposed stimulus. Every part of the cock's leg must receive blows in fighting, but the spur grows on a small and very definite area. As to the bird-of-paradise, in the stage before the plumes were elongated, would such a small number of feathers be separately erected at the will of the excited cock? Mr. Cunningham says that the testis descends into the scrotum in jumping and galloping animals. Why does the ovary not also descend?

Professor R. R. Gates said that the speaker's general point of view was very similar to, if not identical with, one he himself had put forward ten years ago when he contrasted two types of character, mutational (karyogenetic) and recapitulatory (organismal). This was in the nature of a *tour de force*, for he doubted whether acquired characters existed; but if they did, the characters to which they gave rise would be such as he had defined as organismal.

On the invitation of the President, the meeting, by applause, thanked Mr. Cunningham for his paper, and the President then asked him to wind up the discussion.

The author stated, in reply to Mr. Pycraft, that he had definitely excluded colour from his argument, and that in most of

the cases mentioned by Mr. Pycraft the two sexes were similar and showed none of the sex-limited characters which the author had attempted to explain. The helmet or casque of the Cassowary was present in both sexes.

In reply to Professor Garstang, he said that the testis is the heaviest organ in the abdomen in proportion to its size, and is the most loosely attached.

23rd January, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 9th January, 1930, having been circulated, were taken as read and confirmed, subject to corrections in the scientific report which have been received by the Secretaries.

Arising out of the minutes, the President reported that, as instructed by the Society, the officers had communicated the views of the Society in regard to Syon House to the 'Times' (11th January), and 'Nature' (18th January).

The President read the following letter from the Under Secretary of State, Colonial Office :—

Downing Street,
21st January, 1930.

Gentlemen,—

I am directed by Lord Passfield to acknowledge the receipt of your letter of the 3rd of January quoting the text of two Resolutions which were passed at General Meetings of the Society in November and December relative to the proposed introduction of Black Buck (*Antilope cervicapra*) into Ceylon, and to inform you that a copy of your letter is being sent to the Governor of Ceylon.

I am, Gentlemen,
Your obedient servant,
H. R. Cowell.

The Zoological and Botanical Secretaries,
Linnean Society of London.

The President called attention to the new forms of recommendation for Foreign Members and Associates.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-Laws and was admitted :—Christopher Allan Hector Perera Jayawardana.

The following candidates, whose names were read for the third time, were balloted for and elected Fellows:—Robert Benson Ewbank, C.I.E., Francis Kingdon Ward, and Joseph Calvert.

The Botanical Secretary exhibited the copy of a picture in the British Museum of the Mogul School (17th century), showing a tame Black Buck in a leash.

Dr. A. B. Rendle, on behalf of the authors, gave a summary of the paper entitled "Aylmer Bourke Lambert and his 'Description of the genus *Pinus*,'" by Mr. H. W. Renkema and Mr. John Ardagh.

Aylmer Bourke Lambert, the son of a country gentleman, of Boyton, Wiltshire, was one of the wealthy amateurs of the late 18th and early 19th centuries to whom science generally and botany in particular are deeply indebted. Among his friends at Oxford, where he matriculated in 1779, were Joseph Banks and the principal founder, in 1788, of our Society, James Edward Smith. Lambert was an original Fellow of the Society, and at his death in 1842 the last surviving original Fellow. For fifty years he was Vice-President, and to him, in the frequent absence of the President, fell the duty of conducting the Society's affairs. The early volumes of our 'Transactions' bear witness to his versatility, including communications by him on the Indian *Bos frontalis*, the Australian *Macropus*, Rust of Wheat, and the North American water-grass, *Zizania aquatica*; while his two separate publications on the species of *Cinchona* (1797, 1821) embody the results of his own systematic study of the genus and the collation of papers by other workers.

Lambert's chief contributions to botanical science were the accumulation of a large library and herbarium, (which, like that of Sir Joseph Banks, was freely open to other workers and a meeting place for botanists), and the spacious monograph of the genus *Pinus*, which is the subject of the present communication. Lambert's librarian and curator was David Don, who for many years (1822–41) was the Linnean Society's librarian. The herbarium, together with the library, pictures, and other effects, were sold by auction at Lambert's death in 1842. An annotated copy of the sale catalogue in the Department of Botany, British Museum, indicates the purchaser of, and the price paid for, the various lots. Robert Brown, then Keeper of Botany, secured many valuable items for the Museum, including the important South American Collections of Ruiz and Pavon, the authors of the 'Flora Peruviana et Chilensis' (1798–1802).

The monograph, the first edition of which, in folio, was published in 1803 (vol. i.), 1807 (Appendix), and 1824 (vol. ii.), is a magnificent work, illustrated by such pre-eminent botanical artists as the brothers Bauer, and produced in the most sumptuous style. A second edition appeared (1828–37) shortly after the completion of the first. This included a third volume (1837) containing

descriptions and plates of additional species, which is sometimes erroneously assigned to the first edition. Two other folio editions in three volumes were subsequently issued (1837–42, 1838), copies of the second of which are now remarkably rare; the authors of this communication have not seen it. In 1842 a 4to (sometimes described as 8vo) edition appeared, in which the plates prepared for the original edition are cut down to suit the smaller format. This is the edition most frequently found in libraries.

Unfortunately, the canons governing the issue of scientific publications were less rigid in the early 19th century than those on which we insist to-day, and considerable confusion has arisen owing to the rarity of copies of the various folio editions and the somewhat haphazard way in which the contents of the volumes were put together. Citation of plates and descriptions are often difficult to check.

The present communication embodies a detailed description of the contents of all the copies of the volumes of the various editions to which the authors, in Holland and London respectively, have had access or on which they have been able to obtain reliable information. Appended are tabulated lists of the complete contents of each volume compiled as the result of their investigations.

Mr. S. Savage referred to the great care necessary to produce a successful result in this intensive form of bibliography, and showed from unpublished MS. sources in the Society's archives that both Sir Joseph Banks and James Edward Smith helped Lambert in selecting the drawings to be engraved and with the manuscript; that the edition of the first volume was limited to 200 copies, 25 of which were coloured by William Hooker, the illustrator of R. A. Salisbury's 'Paradisus Londinensis'; and that the earliest-issued coloured copies were on inferior paper.

The President expressed the thanks of the meeting to the authors, and to Dr. Rendle for his exposition of the paper.

Dr. T. A. Sprague and Mr. J. Hutchinson exhibited lantern-slides and photographs of the landslide at Gore Cliff, Isle of Wight. A detailed account of the landslide and its geology, by Mr. G. W. Colenutt, F.G.S., has already appeared in the 'Proceedings of the Isle of Wight Natural History and Archæological Society' for 1928 (vol. i, part ix, pp. 560–570, pls. 1–4, 1929). The object of the exhibit was to draw attention to the opportunity for studying the gradual development of the new vegetation on the long slopes and heaps of Upper Greensand boulders which occupy the greater part of the site. When the area was visited in September 1929, a year after the occurrence of the landslide, the new vegetation was found to consist of 72 species of Flowering Plants and two Mosses. The occurrence of about half these species is apparently due to wind-carriage of seeds and fruits from the immediate neighbourhood, numerous

Compositæ, and various species of *Rumex*, *Epilobium*, and Grasses falling in this category. Perhaps a quarter of the species owed their presence to rhizomes, tubers, roots, or occasional sods from the original surface. A few, including *Agrimonia Eupatoria*, *Cynoglossum officinale*, and *Galium Aparine*, seem to have been carried by rabbits or cattle, and *Sambucus nigra* and *Solanum Dulcamara* by birds. Three species were dominant: Charlock (*Sinapis arvensis*), which had evidently sprung up from seeds lying dormant in the soil, there being none in the neighbourhood, *Equisetum arvense*, which had grown from tubers, and *Reseda Luteola*, which had apparently seeded from the neighbouring area.

Professor E. J. Salisbury emphasized the danger of attributing the order of appearance of the primary colonizers to the relative efficiency of dispersal mechanisms alone. The surface of landslides commonly consisted of subsoil and not soil, and as such was deficient in humus and micro-organisms such as bacteria and fungi. Some of the earliest arrivals are probably species which, like *Reseda Luteola*, appear to be extremely tolerant of subsoil conditions.

The study of such areas also affords evidence of the importance of soil aeration, and especially reduced resistance of that soil to root-penetration. *Anthyllis vulneraria*, for example, has a rooting depth in chalk downs normally attaining from twelve to eighteen inches, whereas in the loose soil of the chronic landslide at Folkestone the root will attain to over three feet.

Mr. A. J. Wilmott congratulated Dr. Sprague upon having obtained such a good photographic record of this event. The complete lists of initial species are essential to a study of the means of dispersal of the species which gradually arrive.

Mr. H. N. Ridley spoke from personal knowledge of the area, and welcomed the detailed study of its colonization. The way in which different kinds of dispersal aid distribution are of great biological interest.

Mr. J. C. Shenstone remarked that when a space is cleared upon the London Clay stratum of Essex and of London, the subsequent flora invariably follows a certain order: first, seedlings from seed contained by the soil of the landslide, mostly seedlings of plants frequent on the East coast, whilst on cleared building-sites in towns we have mainly seedlings from culinary plants, with a few introductions by birds or wind, and other casuals. But all these earliest floras on London Clay are invariably completely smothered and destroyed within some three or four years by a strong growth of Coltsfoot (*Tussilago Farfara*), which in due course dies off, and a more permanent flora becomes established.

Mr. Ramsbottom agreed that the recognition of initial colonizers in such studies is of importance, but their distribution in the exposed area should be studied in relation to the biological state of the soil. Subsoil is sterile even for bacteria and fungi, whereas what resulted when only the soil was disturbed was indicated by Flanders poppies.

The President asked whether *Anthemis* occurred as a colonist, for it was a very common plant on stone-heaps in some districts.

Dr. Sprague, in reply, said that the list of plants did not include *Anthemis*. He thanked the various speakers for helpful suggestions for further work.

Mr. G. Tandy gave a paper entitled "Sundry observations on *Caulerpa*," of which the following is an abstract:—

The genus *Caulerpa*, which is also the family Caulerpaceæ, is very sharply cut off from all other plants. The plant-body is a highly specialized cœnocyte and yet is strongly reminiscent of higher plants in form. There is a creeping stolon bearing variously shaped "leaves" and very much branched rhizoids. On the low wooded islands and inner reefs of the Australian Great Barrier system, two species are of importance as sand- and shingle-binders, and it is probable that nowhere else in the world are conditions so favourable for this habit. They are in the broad sense (for they are polymorphic) *C. racemosa* (Forsk.) J. C. Agardh and *C. cupressoides* (Vahl) C. A. Agardh. Batt Reef, which belongs to an inner series and is not a linear or true barrier reef, is a rough oval some ten miles by four. Its surface is calcareous sand almost entirely, and most of this is populated by *Caulerpæ*; conspicuously *C. cupressoides*. *C. racemosa* is very common on Low Isles and is a member of the turf of the Mangrove park, with *Thalassia*, *Halophila*, and *Halimeda*.

Mr. A. D. Cotton pointed out that the peculiar efficiency of the species of *Caulerpa* referred to as sand- and mud-binders lay not only in their abundant development of rhizoids, but in their extensive and intertwining system of rhizomes and runners, which was unique amongst the larger algæ. He enquired if the various named varieties which were included under *C. racemosa* could be correlated with definite conditions of habitat. In Natal he had observed a peculiar and very dwarf form which was reduced to a mass of rhizomes and very short upright branches, and which was probably induced by severe wave-action. Owing to the possession of rhizoids and rhizomes, *C. racemosa* lent itself to transplanting, and it should be possible to test such points by experiments.

Dr. D. H. Scott said he had been delighted to renew acquaintance with *Caulerpa*, one of the most fascinating plants.

Mr. H. N. Ridley said that *C. racemosa* was eaten in the Malay Straits, where it was known as sea-grapes.

The President commented on the complexity of form exhibited by these plants, and enquired if there were any parallel among cœnocytic fungi; and also if there were any cytological data available. He pointed out the obvious advantage of having a Botanist on an expedition like that to the Barrier Reef.

Mr. Tandy, in reply, said that polymorphism could be elucidated only by experiment, and that the comprehensive *C. racemosa* was necessary meanwhile. There is no parallel among cœnocytic fungi, and cytological details are meagre.

6TH FEBRUARY, 1930.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday the 23rd January, 1930, having been circulated, were taken as read and confirmed, subject to corrections in the scientific report which had been received by the Secretaries.

A list of names of those who have made gifts to the Library since the previous Meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-Laws and was admitted:—Joseph Calvert.

Certificates of recommendation of the following candidates for Fellowship were read for the first time:—J. E. C. Turner, Canon Henry Kingsmill Moore, and Phyllis Maude Taylor.

The PRESIDENT exhibited a pair of shoe-laces, and commented on their zoological interest as illustrating a remarkable characteristic of the Delphinapteridæ. This Family, the only recent species of which are the White Whale (*Delphinapterus leucas*) and the Narwhal (*Monodon monoceros*), both Arctic animals, differs from other Cetacea in the structure of the skin. The epidermis in this Order is normally in immediate contact with the blubber, a thick layer of dermis containing a great quantity of oil or fat. In the Delphinapteridæ the epidermis is separated from the blubber by a superficial layer of dermis, which by suitable treatment becomes leather of excellent quality, generally known as "Porpoise leather." The laces exhibited have more elasticity than ordinary leather, and it seems probable that they are actually products of *D. leucas*, as indicated by the designation "Genuine White Whale Buckle Laces," under which they are being sold. The White Whale has been captured in limited numbers, during recent years, chiefly by vessels operating from Norway.

Major S. S. Flower and Dr. W. T. Calman commented on the interest of the President's exhibit, and Mr. H. W. Monckton expressed the thanks of the Meeting.

Prof. R. RUGGLES GATES gave a lecture, illustrated with lantern-slides, entitled "Vegetation of the Mackenzie River Valley."

In 1928 the speaker made an expedition down the Mackenzie River, accompanied by Mr. K. Mellanby as assistant. The party travelled by rail 300 miles northwards from Edmonton, past Lac La Biche to a branch of the Athabaska River at Waterways, which is the terminus of the railway and may be regarded as the

beginning of the Mackenzie system; thence by river steamer down the Athabaska, across Lake Athabaska, and down the Slave River to Fort Fitzgerald. Rapids at this point necessitated a detour of 16 miles by motor-car to Fort Smith, from whence another steamer took them northwards down the Slave River, across the western end of Slave Lake, stopping at Fort Resolution and Hay River; and thence down the Mackenzie River with many stops, until the delta was reached at Aklavik, an Eskimo village in lat. about 68° N.

Throughout this vast area the white population inhabit a few villages hundreds of miles apart, usually consisting of a mission, a post of the Royal Canadian Mounted Police, a branch of the Hudson's Bay Company, and a few trappers with their families. The only means of communication are the rivers and lakes in summer and by dog-train during the long winter. The Indian population is very sparse, numbering a few thousand members of different but related tribes. Their numbers were decimated to the extent of 10 per cent. in some centres in the summer of 1928 by an epidemic of influenza, to which they are very susceptible.

In the valleys of the Slave and Mackenzie Rivers the summer temperatures are remarkably high. At Fort Smith, on Slave River, on July 21st the temperature was over 92° F. at 6 P.M. in the cabin, and at Providence, farther north, summer temperatures ran up to 95°. Even north of the Arctic Circle a temperature of 77° F. was recorded at 10 P.M. on July 29th. Nevertheless, the nights are always cool. In winter the lowest temperature recorded at Fort Smith was 71° F. below zero, and temperatures of 30°– 40° below are usual. The snowfall, however, throughout the north is relatively low, and a lack of precipitation is one of the difficulties of cultivation in places like Fort Simpson on the Mackenzie River. Mosquitoes are a terrible scourge, especially on the open tundra in the far north, where they are more numerous than on the Amazon, but fortunately carry no malaria; it would be difficult for a white man to live without a mosquito-net.

At Providence, a small collection of wooden houses and shacks, near the source of the Mackenzie, in Lat. 61° N., the ground is permanently frozen about 7 feet below the surface, and there are said to be no earthworms.

The Athabaska is a large river, with banks lined with forests of spruce and poplar, *Populus tremuloides* (aspen), *P. monilifera* (cottonwood), and *P. balsamifera* (Balm of Gilead). The Liard River, a tributary of the Mackenzie, derives its name from the French Canadian name of the last tree. Frequently pure stands of poplar are seen on the Athabaska River, alternating with pure stands of spruce (*Picea alba*); in other places they are intermingled. The forests continue for 1000 miles down the Mackenzie, the poplars becoming less abundant northwards. Before the Arctic Circle is reached the spruces have greatly diminished in size, and the poplars have nearly disappeared. The tree-line extends

nearly to the Arctic coast, but there is a wide belt of treeless tundra-like vegetation along the coast, and in some places, even south of the Arctic Circle, the forest-floor contains many lichens.

Great Slave Lake is larger than Wales, being 250 miles from east to west. Hay River at its western end derives its name from the areas of natural prairie along parts of the river and lake. Similar areas are found on the Slave River, also on the Mackenzie north of Providence, on its tributary the Horn River, and elsewhere. They serve as a source of hay for the cattle belonging to the missionaries, and in summer the cattle are carried considerable distances in boats to feed on some of these natural pastures. There seems no doubt that these relatively small areas of grassland along the water-courses are outliers of the great prairie regions farther south. They are certainly not tundra, true tundra in the Mackenzie valley occurring a thousand miles farther north.

Where the Slave River flows into Great Slave Lake it forms an extensive silted area of low, rich soil with many channels. Between the shallow channels are long mud bars just below water level with numerous stranded tree-trunks, and the slightly higher parts are covered with a rich vegetation consisting chiefly of willows, alders, sedges and grasses forming a marsh. The species collected here included *Salix lucida*, *S. candida*, with leaves densely tomentose on the under surface, *S. longifolia*, a small species with long narrow leaves and red stems, abundant all along the Mackenzie, *S. Webbiana* and *S. petiolaris*. Alders frequently form a taller zone behind the willows. *Alnus incana* occurs all the way to the Arctic, *A. tenuifolia* was found at Hay River, while *A. alnobetula* was obtained only from Wrigley northwards. The herbaceous forms on Slave River included such species as *Fragaria virginiana*, *Pyrola secunda*, *P. asarifolia*, *Epilobium angustifolium*, *E. glandulosum*, *Rosa acicularis* var. *Bourgeauana*, *Ribes triste*, and *R. Hudsonianum*. All but the first species occur also within the Arctic Circle. Wild strawberries are plentiful near Fort Simpson and of excellent flavour, so that no attempt is made to grow the cultivated varieties.

The Mackenzie River flows out of the north-west corner of Slave Lake as a broad river of clear water, with numerous islands forming a beautiful archipelago. Some of these islands are said to be covered with mosses (*Sphagnum*) over 10 feet deep. *Sphagnum* is widely distributed, and is gathered and dried by the Indians to line their "baby boards."

At Fort Simpson (Lat. 62° N.) vegetables are grown successfully, including potatoes, cabbages, radishes, celery, beets, and even maize. Considerable oat- and wheat-fields are grown here by the missionaries, and specimens of barley were also obtained. Probably the wheat-line will ultimately extend north to this latitude. The summer rainfall is low, and the high bank of the Mackenzie here is an added difficulty in getting water.

The next stations on the river are Wrighley, Norman, which is at the mouth of the river from Great Bear Lake, and Good

Hope, which is close to the Arctic Circle. From Simpson to Norman is 350 miles. Uniformity is the most striking feature of the vegetation over this vast area—interminable conifer forests, in which the trees get progressively smaller and the vegetation gradually takes on a more Arctic character. The young conifers along the banks frequently show peculiar hypertrophied growths, apparently resulting from wounds caused by the ice when it is swept down the river in the spring floods.

Among the most characteristic herbaceous plants on the river, banks are *Castilleia miniata* and *C. pallida*, *Parnassia palustris*, and *Gentiana serrata*, forming masses of red, white, and blue flowers adjacent to willows and Equisetums. The last cover stretches of mud-flats, especially in the far north, looking in the distance like green lawns, and with a background of low willows which may also grow intermingled with them. The different species of *Equisetum* (of which six were collected) vary in height from a few inches to several feet. Locally they are called goose-grass, as they are eaten by the wild geese on their journeys north and south. *Linum Lewisii*, *Epilobium glandulosum*, *Rubus Chamæmorus* (the cloudberry, or low bush salmonberry), and *Rosa acicularis* are also common, as is *Potentilla anserina*, which shows a wide range of variations. The most glabrous form was found in the far north at Aklavik. *Cornus stolonifera* is called "red willow," and by the Indians "kinnikinnick." They use the inner bark, mixed with tobacco, for smoking.

Ferns appear to be uncommon throughout this area, the only one collected being *Woodsia ilvensis*, at Fort Chippewayan, on Lake Athabaska. It extends north of the Arctic Circle.

At Aklavik a night expedition northwards down the western channel of the Mackenzie delta was made by motor-boat to examine the vegetation in this treeless area of rolling hills. While it has many features of tundra (the soil is always frozen to near the surface and contains abundance of water), yet there are characteristic differences from the tundra of Lapland, and it seems best to call these treeless areas Arctic prairie, on account of the high proportion of grasses. True tundra, with fewer grasses and more lichens, is also found, and no sharp line can be drawn between the lichen-tundra and the Arctic prairies, which form a richer food for the innumerable caribou. Numerous minor variations occur in the character of this vegetation in different areas, but everywhere the conspicuous elements are (1) lichens, (2) mosses, (3) grasses, (4) herbaceous flowering plants, especially sedges, heaths, and orchids, (5) dwarfed woody plants.

The lichens are the usual tundra forms, but they never make up more than one-third of the ground-covering in this area (*cf.* "Lapland Tundra," Gates in Journ. Ecol. vol. xvi, pp. 150–160, 1928). They are more abundant on the higher levels. The grasses are conspicuous and often predominant on hillsides, although not many species are represented, including *Deschampsia cæspitosa*. They occur in clumps known as "niggerheads," with

mosses frequently interspersed in the depressions between, making walking very difficult. One often sinks two feet deep into mosses. The flowering plants include *Spiræa betulifolia*, *Ledum palustre*, *Castilleia pallida*, *Empetrum nigrum*, *Chamænerium angustifolium*, *Carex* spp., and a surprising variety of others. The woody forms, reduced to creepers except in depressions or along the shore, include *Salix glauca*, *Alnus alnobetula*, and *Betula glandulosa*, which has the same habit as *B. nana* in Europe. *Lycopodium annotinum*, found here, is a new record for the region north of Slave Lake.

After remarks by Dr. A. B. Rendle and Mr. A. J. Wilmott, the President thanked the speaker for his attractive account.

Dr. G. P. Bidder read his paper entitled "The Importance of Cataclasms in Evolution," of which the following is an abstract:—

A cataclasm is the result of an exceptional drought, flood, heat, cold, volcanic disturbance, or change in constituents of atmosphere or ocean or other change in environment, which over a large area is fatal to all species or individuals saving those which are exceptionally provided, quantitatively or qualitatively, so as to survive the ordeal.

Darwin recognized the importance of the cataclasm, but he rarely emphasized it, probably because diluvial doctrines had so long held the field. It is often overlooked in theoretical discussions. The possibility of a given species-character or individual variation having survival value is commonly discussed from the point of view only of normal environment, without recognizing that eschatological environment has equal or greater importance in the selection of races, and in regard to many characters must have been the only decisive factor.

If a small heritable quantitative difference can lead to the survival of an individual in a catholic danger which destroys all individuals of the species not endowed with such a difference, then, though the danger recurs but once in 50,000 years, that difference must eventually be stereotyped as a character of the species. In the intervening 50,000 years of peace many successful variations may take place which do not include this saving difference, but they are pruned by the next similar cataclasm, the survivors of which will again all conform to type. Thus cataclasmic selection may enforce specific characters which are normally useless.

Dr. Bidder urged that it is best to keep the word "cataclysm" to its original technical significance of a widespread submergence of land; a "cataclasm" may be defined as the phenomenon of a populous region of earth or sea, reduced by some violent happening to sterile emptiness, which is repopulated by the few survivors of the disaster. Destruction may come upon all living beings from a volcano, from a volcanic wave upon land and freshwater organisms, from a pandemic disease upon one

group of animals only. The survivors from the Black Death in London were selected for a physiological difference which enabled them to resist a single disease; this difference may have made them inferior men in other respects. Since many centuries of normal environment had not selected this difference, it probably did make them inferior men in normal environment.

The Black Death killed up to half the population, but we are considering especially cataclasms after which not 1 in 1000 is left alive. The problem had presented itself to the speaker in regard to littoral sponges. He had maintained * the thesis that the well-known evolution of the canal-system in sponges results in progressive increase of the power in the jet from the vent to carry the used water away from the intake of the sponge. On the rocks at Plymouth grow in profusion *Halichondria*, *Grantia*, and *Sycon*, all with powerful jets from the vents. Yet they live between tide-marks in the surf and swirl of the sea, where such jets are absolutely of no value. This is explained if we consider that, once in a century or so, either very heavy rain or very hot sun at a low spring-tide, may kill every sponge on the shore; when the repopulation must take place from the larvæ of such sponges as have lived, though ill-nourished, in some shut-in submarine cave, maintaining life in the still water because of their powerful current-system.

We see that cataclasmic selection may enforce a character which (1) may be of no benefit in normal life; (2) may carry, associated with it, characters selected by environment before the cataclasm and transmitted because they were possessed by the only surviving organism; while (3) small quantitative differences may have survival value in a cataclasm. Darwin † explains the long neck of the giraffes because "the individuals which were the highest browsers, and were able during dearths to reach even an inch or two above the others, will often have been preserved." In normal times a giraffe two inches taller might gather one per cent. more leaves than her sister, and be perhaps half per cent. better nourished, which would rarely make any difference in survival. But when all the ground is eaten bare, and trees stripped clean to the full height that giraffes can reach, a giraffe two inches taller will find on every tree two inches of untouched leaves on which she may make a meal that will enable her alone to survive the dearth, and to transmit her slightly longer neck to her progeny, which possess the country after the cataclasm.

We may tentatively consider whether some unsolved zoological problems may not be explained by cataclasmic selection. At the onset of the glacial period, might a mutational madness have induced some lemmings to wander, regardless of obstacles, so that they attained southern climates while their sane relatives

* Quart. Journ. Micr. Sci. 1923, lxvii, p. 293.

† 'Origin of Species,' 6th Edition, p. 177.—Pycraft (Sc. Progress, Jan. 1930, p. 442) fails to notice that in this case Darwin carefully explained the value of a *small* variation.

perished in the north? If so, with the retreat of the ice, those of their descendants who inherited the madness would in part wander back, and repeople Northern Europe with a lemming population to which wandering madness was transmitted. Have our ancestors ever been through a crisis from which only those possessed with madness could escape, and does this explain some psychology, particularly in the behaviour of crowds? May the great lateral spread of horns in some Bovidæ have saved their ancestors from being crushed to death in the stampede from a devastating fire? Insects fly out before the smoke from a forest on fire; may the need for this have selected their delicate olfactory sense as much as sex or food? May the wax in bees' cells protect the pupæ from poisonous fumes, and so have been selected by forest-fires? May the high development of the spleen, which saves a man after moderate poisoning by carbon monoxide, have been forced upon mammals by forest- and prairie-fires? Remembering Dr. G. S. Carter's hypothesis* that fishes took to breathing air because of the lack of oxygen in tropical swamp-water, did progressive suffocation in the carboniferous swamps kill off all freshwater fish which had not become amphibious? The two great groups of insects and birds each show remarkable similarity of plan in most of their members; can that be because the insects are descended from a few winged survivors of the pre-Cambrian deluge†, and because the flying birds were exterminated when mammals suddenly acquired the power of swift motion, all but one group of birds, which had learned to perch on a thin twig? In general, is it possible that in other groups the recognition of cataclasmic selection may explain otherwise inexplicable characteristics?—as it appears to do in littoral sponges.

Prof. E. B. Poulton said that Dr. Bidder had put forward a most interesting point of view, worthy of much reflection. Some years ago Prof. Poulton had come to a similar conclusion with regard to the whelks of the Red Crag, which are all sinistral. The explanation he suggested was that a sudden refrigeration had killed all but one whelk, which happened to be sinistral, and that her progeny had repopulated the Crag.

Dr. W. T. Calman objected that important changes in an animal involved changes in many different parts. The transition from water-breathing to land-breathing involved many elaborate co-ordinate changes, which could not have been effected in one stroke by a catastrophe—the word he still preferred.

Mr. J. L. Chaworth-Musters would act on Dr. Bidder's invitation for correction of his facts. The lemming lives under snow and is liable to be attacked by bacterial disease; he did not believe that the Norwegian lemming migrates far. The disease makes them

* Proc. Linn. Soc. (18th April), 1929, p. 53.
† Brit. Assoc. Rep. (Leeds), 1927, p. 60.

very thirsty, and they struggle in any direction to obtain water; when they have found it they rush in and lap it up, often dying as they drink it, often pushed in by their thirsty fellows and drowned. The disease has been investigated, because human beings catch it, particularly from drinking water where lemmings have been; the disease excites thirst in human beings also. For five years at a time no man knows where the lemmings are; the speaker believed that they are in burrows 10 feet below the surface in the peat-bogs. At length their increasing numbers make the burrow so foul that they become diseased and have to come up.

Mr. M. A. C. Hinton could quite believe all that the last speaker had said, because the habits of the lemmings are so mysterious that we really do not know what an adult Norwegian lemming is like. Answering a query from Dr. Bidder, he said that the movement of rats is different; rats scatter through shortness of food, but do not move in large masses. Voles are another question.

Mr. F. H. Lancum asked if it was certain that the progeny of a long-necked camel would have long necks?

Mr. I. H. Burkill described the bare patches that strike the eye on the mountain-ranges in Malaya, where land-slides have taken place. On these patches are found very rare orchids and other plants which are hardly met with elsewhere. He was of opinion that these rare plants are produced by evolution due to recurrent cataclasms.

The President agreed that in the circumstances postulated by Dr. Bidder certain characters which have no survival value under normal conditions might well prove effective in preserving individuals from destruction. He suggested that it would be very difficult to ascertain that cataclasms had often been instrumental in influencing the course of evolution.

Dr. Bidder, in replying, thanked Prof. Poulton for his very valuable illustration. Dr. Calman had misinterpreted his words: a cataclasm could cause no variation, only select it; suffocation in the coal-swamps could kill off all fish that were not air-breathers. He was puzzled by the interesting statements from Mr. Chaworth-Musters and Mr. Hinton, because Wiman* certainly seemed to describe the lemmings' mass-migrations at first hand, and it is difficult to neglect the accounts of persons who have seen large masses of rats in passage. Answering Mr. Lancum, the long neck of the camel would probably be inherited by her offspring to the same degree as Galton had shown the stature of tall human parents to be inherited. Dr. Bidder thanked Mr. Burkill for his welcome support, and the President for his kind words; cataclasmic selection, he believed, had really played a considerable part in evolution, and he must confess to retaining his hypothesis that the winged insects are an example of its action.

* Paläont. Zeitschr. (Berlin, 1913), i, p. 147 (*fide* J. Weigelt, 1927).

20th February, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday the 6th February, 1930, having been circulated, were taken as read and confirmed, subject to corrections in the scientific report which had been received by the Secretaries.

A list of names of those who have made gifts to the Library since the previous Meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—William Alexander Francis Balfour-Browne, Edgar Johnson Allen, and Eustace Rolfe Gunther.

Certificates of recommendation of the following candidates for Fellowship were read for the second time:—J. E. C. Turner, Canon Henry Kingsmill Moore, and Phyllis Maude Taylor.

A discussion on the possible relationship between Lampreys and Ostracoderms was held, in which the following speakers took part.

Sir Arthur Smith Woodward gave a general account of recent discoveries of the oldest known fish-like organisms, which were named Ostracodermi by Cope, and regarded by him as closely related to the lampreys and hag-fishes. He showed how new fossils from the Upper Silurian (Downtonian) of southern Norway described by Prof. J. Kiær, and from the Upper Silurian and Lower Devonian of Spitzbergen described chiefly by Dr. E. A. Stensiö, confirmed this interpretation of the group.

The speaker considered the fusiform and freely-swimming Anaspida as the most generalised Ostracoderms hitherto discovered. Kiær's specimens of new genera and species from Norway showed the dermal plates of the head clearly, and proved that Traquair described the first Anaspids, *Birkenia* and *Lasanius*, upside down. The top of the head shows a median narial opening just in front of the eyes. The mouth is not satisfactorily known, for there must have been a soft rostrum. The body-lobe in the tail bends downwards, not upwards. A similar "hypocercal" condition has been observed by Stensiö in the larva of the lamprey. Dermal plates and small spines immediately behind the row of gill-openings seem to represent paired pectoral fins. These have now also been observed by H. C. Stetson in new specimens of *Birkenia* itself.

Among Heterostraci, the most important recent discovery is that of the dermal plates round the jaws observed by Kiær in a specimen of *Pteraspis* from the Downtonian rocks of Spitzbergen. The mouth was a transverse slit on the lower side of the head, and round it are dermal plates bearing minute denticles which can scarcely have conformed to the endoskeleton of ordinary gnathostome jaws.

Our knowledge of the Osteostraci, or Cephalaspidians, is extended in a remarkable manner by Stensiö's great memoir on the Cephalaspidæ published by the Norwegian Academy of Science at Oslo in 1927. Beneath the head-shield there is a partially ossified or calcified endoskeleton, and all the blood-vessels and nerves penetrating this or lying in contact with it are contained in calcified tubes which are preserved in the fossils. With great skill and patience Stensiö has prepared these for study in many specimens, and has interpreted them by reference to the lampreys. The gills must clearly have been in pouches, and they extend so far forwards that the anterior parts of the visceral skeleton cannot have been transformed into jaws. The median narial opening in front of the eyes is proved to have been at the anterior end of the brain. The otic capsule is so well preserved as to show that only the two upper semicircular canals are present, as in the lampreys. Large nerves extending upwards and outwards from this hinder region may perhaps be rightly interpreted as connected with electric organs above the gill-chamber and in a median depressed area in the shield behind the eyes. Finally, Stensiö agrees with the late W. H. Gaskell in regarding the soft cartilaginous endoskeleton of the head of the larval lamprey as homologous with that of the Cephalaspidians.

Professor E. S. Goodrich made the following contribution, entitled "On the Relationship of the Ostracoderms to the Cyclostomes":—

Professor Kiær (1), in a remarkable paper on the Anaspida, included these extinct Ostracoderms together with the Cephalaspidomorphi, in the Branch Monorhina. Later, Prof. E. A. Stensiö (4), in a no less valuable work on the Cephalaspidæ, went further and placed all the Ostracoderms (with the exception of the Pterychthyomorphi) together with the Cyclostomes in one Class Ostracodermi (Cyclostomata).

While I have the greatest admiration for the skill and accuracy of the work of Prof. Stensiö, and consider that he has greatly added to our knowledge of the Ostracodermi, I am unable to accept some of his conclusions without more convincing evidence. Stensiö maintains that the palæozoic Ostracoderms are closely related to the Cyclostomes; that ancestral primitive Ostracoderms, provided with denticles, with a bony skeleton, and probably with rudimentary paired fins, diverged into two branches. According to him, one branch, the Cephalaspidomorphi (Anaspida and Cephalaspidæ) led towards the modern Petromyzontia or

lampreys; the other branch, the Pteraspidomorphi (Pteraspidæ, Cœlolepidæ, Palæospondylidæ (?)), led towards the modern Myxinoidea or hag-fishes. Thus the lampreys would be degenerate Cephalaspidomorphs, and the hag-fishes degenerate Pteraspidomorphs.

Now modern Cyclostomes have no denticles either on the surface of the body or in the mouth, have no bony skeleton, and no paired fins. His theory entails the assumption that all these structures have been lost; and, moreover, lost independently in the two modern groups. We might allow, perhaps, that paired fin-folds may have been lost—other cases of loss of limbs are known—also that the bony skeleton may have been lost; but we cannot so easily allow that denticles, those very persistent structures, have disappeared *; especially when it is remembered that both Petromyzonts and Myxinoids are provided with characteristic epidermal horny teeth. Is it likely that in two separate groups the true teeth would be lost and replaced by horny teeth?

Turning to quite another point. In his reconstruction of Cephalaspids, Stensiö makes out that there are about ten pairs of gill-pouches like those of the Ammocœte larva. But the first is said to be prespiracular, and related to the so-called fifth or trigeminal nerve as the next or spiracular pouch is to the facial nerve. Neither in the Petromyzontia nor in the Myxinoidea is there an open prespiracular gill-slit in the adult, or an endodermal prespiracular gill-pouch related to the trigeminal nerve in the embryo (see further below, p. 48). Moreover, in modern Cyclostomes, not only is there no prespiracular slit, but the spiracular slit itself is closed at an early stage of development—has this peculiarity also been acquired independently in the two groups?

More important, perhaps, than any of these difficulties is that presented by the rasping organ or "tongue"—one of the most characteristic organs of the Cyclostomes. It is a large and powerful structure, armed with horny teeth; it works in and out of the mouth by means of strong muscles, and is supported by cartilages apparently derived from the first or mandibular visceral arch. Its muscles are supplied from the trigeminal nerve. It occurs both in Petromyzontia and in Myxinoidea, their whole life depends on it, their whole organization has been profoundly influenced by its development. Not a trace of it is found in any Ostracoderm! It would surely be absurd to assume that such a peculiar and complex mechanism has been independently developed in the two modern groups.

Why, it may be asked, has it been held that the Cephalaspidomorphi are so closely related to the Lampreys? It is, I think, because they possess a small median dorsal pore in front of the

* It is certain that the Pteraspidomorphi had true denticles; but, it is not so certain that these were present in the Cephalaspidomorphi, though they seem to be represented in the outermost layer of the exoskeleton of some forms.

orbits which is compared to the so-called median nostril of Petromyzon. This pore in the Lamprey is not, of course, a true nostril, but the opening of a naso-hypophysial canal leading from the hypophysis and the paired nasal organs. It occurs only in Cyclostomes, opening at the tip of the snout in Myxinoids, and dorsally in Petromyzonts. In all other Craniates the hypophysis remains ventral and has no connection with the nasal sacs.

If we try to imagine why this unique arrangement was evolved in Cyclostomes, it may be suggested that it was on account of the rasping organ. The action of the latter would tend to block the hypophysial duct, and we may suppose that the originally ventral median opening was carried forwards, became confluent with the nasal openings, and was further carried to the end of the snout. Finally, when Petromyzonts developed a large oral sucker, the opening was shifted on to the top of the head, where it could still function with the sucker in action. This, indeed, is the history of the development of the naso-hypophysial duct in modern Cyclostomes.

Of such a median opening there is not a trace in Pteraspids. Must we also assume that it has been independently formed in Petromyzonts and Myxinoids?

We are forced to the conclusion that the Petromyzontia and the Myxinoidea together form a single monophyletic group; and that, even if derived from some remote Cephalaspidomorph ancestor, the modern Cyclostomes must have acquired some of their most conspicuous special characteristics after they had diverged from the Cephalaspidomorphs. In other words, if the Cyclostomes are related to the Cephalaspidomorphs, the Myxinoids could not have evolved from Pteraspidomorphs in the way suggested by Stensiö.

It may, however, be answered that my criticisms only apply to a part of Stensiö's conclusions, the less important part according to which the Myxinoids have been independently derived from the Pteraspids, and leave unaffected the more important conclusion that modern Cyclostomes are the degenerate descendents of Cephalaspidomorphs. But fresh difficulties arise even if we set aside the Pteraspids as an independent group *.

For then it must presumably be supposed that the very exceptional dorsal position of the median pore must have already been acquired by the common ancestor of extinct Cephalaspidomorphi and the two modern groups, and that the more ventral position of the pore in Myxinoids is secondary. It is strange that the pore should be even further back on the head in Anaspida (actually passing behind the anterior level of the orbits) than in the Lamprey. Also, since the extinct Cephalaspidomorphi have no rasping organ, no explanation seems adequate for the

* The Pterychthyomorphi must also be set aside, since they have no median pore. Yet they and the Cephalaspids have many and important points of resemblance in common.

formation of a naso-hypophysial duct, or for its shifting on to the top of the head, since they have no sucker.

That the median pore in Cephalaspidomorphi led to a naso-hypophysial canal does not seem to me to have been proved. Their nasal sacs might well have been situated near the mouth, and the olfactory nerves might perhaps have passed through the paired ventral so-called carotid canals described by Stensiö.

If the median dorsal opening in the fossil Cephalaspidomorphi is not a naso-hypophysial pore, what can it be? Possibly it is a pineal foramen. For the pineal eye is not a truly unpaired organ; there are in Craniates right and left pineal organs, which take up a median position. In Petromyzonts the right pineal is the larger and more differentiated, the left remaining below it. But it is possible that in early vertebrates both were functional, one occupying the anterior pore, the other the more posterior pineal pit between the orbits*. But, whatever may be our interpretation of the nature of this pore, alone it seems not to afford sufficient evidence for determining the affinities of the Cephalaspidomorphi.

It is sometimes stated that the gills of Cephalaspids resemble those of Cyclostomes. It is true that their small external openings recall those of the modern forms (also the spiracles of Selachians); but the chief characteristic of the gills of adult Cyclostomes is their enclosure in almost spherical sacs which communicate with the alimentary canal by means of narrow cylindrical ducts. Of the existence of such sacs and ducts there is no evidence in extinct Cephalaspidomorphi. On the contrary, the fossils seem to show that the Cephalaspids were provided with wide branchial pouches.

Returning, now, to the question of a prespiracular gill. It was mentioned above that according to Stensiö the Cephalaspids were provided with a prespiracular gill-pouch related to the trigeminal nerve (as the spiracular pouch is to the facial nerve) and situated in front of the velum. It is compared to a blind ectodermal pocket developed in front of the velum in the Lamprey. But the velum marks the limit between the ectodermal stomodæum and the endodermal gut. Gill-slits are formed by the piercing of the wall between an endodermal pouch and an ectodermal pit, and it cannot justly be held that the stomodæal pocket of the Lamprey is a true gill-slit. If the Cephalaspid possessed a prespiracular slit it must have developed posteriorly to the velum, and is not represented in the modern Cyclostome †.

In both Cyclostomes and Gnathostomes the three cephalic segments in front of the auditory region are similarly highly

* Again, it seems not impossible that the front pore represents a persistent anterior neuropore, such as occurs in *Amphioxus*.

† No endodermal prespiracular pouch has been found in any Cyclostome, so far as I am aware; but vestiges of it have recently been said to occur in the embryo of *Lepidosteus* (Veit, **5**; van Schrick, **2**). The evidence, however, is by no means convincing.

specialised, and the first or spiracular gill-pouch is related to the facial nerve; if the Cephalaspids had a prespiracular gill-pouch related to the more anterior trigeminal nerve they must presumably belong to a far more primitive type of vertebrate, in which the head had not yet reached the Craniate stage of specialisation *.

Much stress has been laid on the alleged presence of only two semicircular canals (instead of the usual three) in the auditory capsule of Cephalaspids, as in Petromyzonts. It should, however, be remembered that only one occurs in Myxinoids (usually said to be formed by the combination of two), so that the mere number of these canals can hardly be of much importance in classification. Moreover, although only two are outlined in bone, there would seem to be room for a third horizontal membranous canal in the auditory cavity shown in Stensiö's restorations. In this connexion it may be mentioned that the cartilaginous auditory capsule of modern Cyclostomes shows no external or internal sign of the canals, and if fossilised would give no certain indication of the number of canals within.

Without wishing to deny the possibility of a relationship between the Cyclostomes and the palæozoic Cephalaspidomorphi, I would urge that the evidence for the theory that the former are the degenerate descendants of the latter is still weak, and venture to think that this theory will not be established until the difficulties mentioned above have been overcome.

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3. Shipley, A. E. "Development of *Petromyzon*." Quart. Journ. Micr. Sci. vol. lvii, 1887.
4. Stensiö, E. A. "Cephalaspidæ." Norske Vidensk. Akad., Oslo, 1927.
5. Veit, O. "Beitr. z. Kennt. d. Kopfes d. Wirbeltiere." Morph. Jahrb. vol. liii, 1924.

Professor D. M. S. Watson (Visitor), replying to Prof. Goodrich, distinguished the major problem of the relationship of the Ostracoderms in general to the Cyclostomes, and the minor problem of the possible descent of the lampreys and hag-fish from different groups.

The important evidence bearing on the Cyclostome affinities of Ostracoderms is contained in Dr. Stensiö's work on Cephalaspidians. In discussing this evidence it is necessary to distinguish between the facts of structure and the interpretations placed on them.

* It has been stated by Stensiö as evidence of close affinity, that the extremity of the tail of the larval lamprey is bent downwards. This downward bend has not been recorded by other observers, and is not shown in Shipley's carefully drawn figure (3). I have never seen it in living Ammocœtes, nor can I find it in well-preserved specimens. Moreover, it is in the Anaspida alone that the hypochordal type of caudal fin occurs.

In the Cephalaspids nearly all the connective tissue of the dorsal part of the anterior end of the body is ossified, the nerves and blood-vessels alike running for long distances through bony tubes. By his perfect dissections, and models made from ground sections only a few microns apart, Dr. Stensiö has established the course of these canals with complete certainty.

The best evidence of the validity of his interpretation of these facts is that it explains every fact known and gives us a picture of an anatomy much more primitive than that of any recent form, but agreeing exactly with that which has been predicted of an ancestral craniate on the basis of embryology and morphology.

Any serious attack on Stensiö's interpretation must take the form of an alternative reading which is equally complete.

Prof. Goodrich's suggestion that Dr. Stensiö's trigeminus is the facial nerve and that the naso-hypophysial opening is for the parapineal, seem to be unworkable when the rest of the structure is considered.

Dr. C. Tate Regan said that Vertebrates may be divided into two main groups, Cyclostomata, with the gills in separate muscular pouches that expand and contract, and Gnathostomata, primitively with gills attached to the anterior and posterior faces of thin septa, which are supported at their inner ends by skeletal arches, one pair of which is modified into jaws. In the Gnathostomata, respiration is effected by contraction and expansion of the pharynx, produced by movements of the gill-arches; this is quite different to the Cyclostome method.

The evidence produced by Kiær and Stensiö points to the conclusion that the Pteraspida, Anaspida, and Cephalaspida had separate gill-pouches and no jaws, and therefore belong to the same main division as the recent Cyclostomata. It seems fairly certain, however, that none of them had the muscular protrusible tongue, armed with horny teeth, characteristic of living Cyclostomes; this works like a piston and is used to rasp off the flesh of the fishes on which these animals prey; its possession indicates that the modern lampreys and hag-fishes are more nearly related to each other than is either to any of the palæozoic groups.

Mr. G. R. de Beer agreed with Professor Goodrich that it was impossible to accept the view that lampreys and hag-fish had evolved the peculiarities of their structure independently. There remained, however, the larger question as to what the relations were between the modern Cyclostomes as a whole on the one hand and the Ostracoderms on the other. Here the conclusions to be drawn from two separate biological disciplines, viz. Morphology and Embryology, were difficult to correlate. There was the undoubted fact that in several respects the structure of the Cyclostome bore a very remarkable resemblance to that of the Ostracoderm as revealed by Stensiö's researches. If similarity were a clue to affinity, then it was difficult to avoid the conclusion that the Cyclostomes were fairly closely related to the Ostracoderms. But this would entail the necessity of regarding the

Cyclostomes as being very much more degenerate than was supposed.

It is admitted that the structure of the adult Cyclostome betrays marks of degeneracy, but the study of their development, on the other hand, shows them to be very primitive in several respects. It is therefore difficult to imagine that the Cyclostomes have lost all those structures which the Ostracoderms possessed. While Morphology would consider these classes of animals to be closely related, Embryology would suggest that caution is necessary in emphasizing the closeness of this relation.

The President asked the Meeting to express its thanks to Sir Arthur Smith Woodward and the speakers who followed him for the extremely clear and interesting account which they had given of a difficult subject. Whatever difference of view might still exist, all authorities agree that the Ostracoderms are the oldest vertebrates of which we have any knowledge, and therefore their structure and their relationships to more recent vertebrates are of the highest interest to every zoologist. It had been a great advantage to hear Sir Arthur, Professor Goodrich, Professor Watson, Dr. Regan, and Mr. de Beer explaining the bearings of recent work on the Cyclostomes and Ostracoderms from their five different points of view, and the Society was very much obliged for their kindness. He asked Sir Arthur Smith Woodward to reply to the questions and criticisms.

Sir Arthur Smith Woodward said that he could not reply on behalf of Stensiö, and was not concerned to defend his double origin of the Cyclostomes against Professor Goodrich's criticisms. He agreed with Professor Watson and Dr. Tate Regan that this is a matter of detail. The question of interest is not whether the Cyclostomes form one group or two, but whether they are descended from Ostracoderms. He could not accept Professor Goodrich's suggestion that the "olfactory pore" is an anterior pineal eye; in the rare case where two pineal eyes appear in a fossil they are side by side. Taking into account the olfactory pore, the nervous system, the skeleton, and the absence of a horizontal semicircular canal, the evidence left no doubt in his mind that Stensiö has proved the close relationship of recent Cyclostomes to the earliest Ostracoderms.

6th March, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 20th February, 1930, having been circulated, were taken as read and confirmed, subject to corrections in the scientific report which had been received by the Secretaries.

A list of names of those who have made gifts to the Library since the previous Meeting was read and laid on the table.

The following Fellows signed the Obligation in the book of the Charter and Bye-Laws and were admitted:—Joseph Thomas Cunningham and Ernest Philip Foquett Sutton.

Certificates of recommendation of the following candidates for Associateship were read for the first time, and the President announced that the Ballot would take place on the 3rd April, 1930:—John McConnell Black, Harold Stuart Thompson, and Benjamin Storrow.

Certificates of recommendation of the following candidates for Fellowship were read for the first time:—John Scott Thomson, George Simpson, and Robert Burgess.

The following candidates were balloted for and elected Fellows:—Josiah Edgar Carrington Turner, Canon Henry Kingsmill Moore, and Phyllis Maude Taylor.

Dr. Sidnie M. Manton gave an account, illustrated with lantern-slides, of her paper entitled "Notes on the Segmental Excretory Organs of Crustacea.—V. On the Maxillary Glands of the Syncarida," of which the following is an abstract:—

Among the Syncarida the maxillary gland of *Bathynella* and the main coils of the duct of the gland of *Anaspides* have already been described. Detailed reconstructions of the maxillary glands of *Paranaspides*, *Anaspides*, and *Koonunga* have been made from fresh material obtained in Tasmania. The general disposition of the coils of the efferent duct in the maxillary glands of the three types is similar, but there are differences in detail. There is close resemblance between *Paranaspides* and *Anaspides* in the positions of the duct and end-sac. The ducts of *Koonunga* and *Anaspides*, however, resemble each other in possessing a certain loop, but this loop is not formed in the same way in the two animals. The pattern of the duct shown by *Anaspides* and *Koonunga* could have been derived from a type resembling that of *Paranaspides* in general form, but lacking its peculiar features such as excessive duct fenestration. Such a conception of the interrelationships of the glands in the three types is in harmony with conclusions on the affinities of the three animals based upon external anatomy and habits.

The President announced that discussion on the first two papers would take place after both had been read; and called upon Dr. W. T. Calman to give a summary of the Addendum to Prof. G. E. Nicholls's paper on *Micraspides*, with an exhibit of specimens of *Parabathynella*.

Dr. Calman expressed his admiration for the paper which they had just heard, and for Dr. Manton's valuable work on the Syncarida, including the first observations recorded of the natural history of the live Syncarids.

The Addendum to Prof. Nicholls's paper deals with the recently published posthumous paper by the late Prof. G. O. Sars on *Parabathynella malaya*. An unfortunate mistake in one of the figures accompanying the paper is pointed out. Prof. Sars disputed the accepted view that the Bathynellidæ are closely related to the Tasmanian Syncarida, but his conclusions are shown to rest on inadequate consideration of the published evidence regarding their morphology. The Syncarida, in respect both of structure and of habits, form a graded series from the free-swimming lacustrine *Paranaspides* through the creeping *Anaspides*, the mud-dwelling *Koonunga*, and the partially subterranean *Micraspides* to the completely subterranean *Bathynella* and *Parabathynella*.

Mr. J. T. Cunningham asked Dr. Calman if the gradations of habit, which he had described in the Syncarida, are demonstrably associated with gradations of structure. In particular, is this the case in regard to atrophy of the eyes?

Dr. Manton asked if any steps were being taken to examine the internal anatomy of *Micraspides*. In view of Dr. Calman's opinion that its external features and habits place it in the intermediate position of a graded series, it would be most interesting to see if the excretory organ confirms this by showing a similar intermediate position between the excretory organs of the other members of the series.

The President expressed the opinion that Prof. Nicholls had been very fortunate in having Dr. Calman as exponent of his communication, and that the Society was much indebted to Dr. Calman and to Dr. Manton for the clear descriptions of this little-known group, whose importance in considering crustacean phylogeny could not be over-estimated. He asked the meeting to express hearty thanks to both, and called upon Dr. Calman to reply.

Dr. Calman answered Mr. Cunningham that it is impossible to show that gradation of structure is strictly correlated with gradation of habitat. He regretted to tell Dr. Manton that, of the three known specimens of *Micraspides*, it must be regarded as improbable that one will be available for section-cutting.

Mr. Ashley G. Lowndes exhibited three interesting Crustacea from the Marlborough district, and lantern-slides of the same animals.

Chirocephalus diaphanus Prevost occurs regularly and fairly abundantly in three ponds in Savernake Forest. Its occurrence and disappearance seem to be correlated with the presence of two

kinds of eggs and the presence of certain Ostracods and Caddis larvæ.

Niphargus kochianus Bate occurs regularly in most of the deeper wells at Marlborough and Manton.

Eurytemora velox Lilljeborg occurs regularly in the canal at Savernake. Its natural habitat is supposed to be littoral and brackish water, but it seems to be spreading all over the British Isles and living successfully in situations where there is not and never has been any salt water. Eggs from adult females have been hatched out and brought up to maturity in the laboratory at Marlborough in perfectly fresh water.

The President said that in the jar passed round we had been able to see alive the extremely rare representative of another group of Crustacea recognized by all zoologists as primitive. *Chirocephalus* had been little met with in England; Baird recorded it from localities, including Norwich, Epping, Blackheath, and Hammersmith, in some of which the intervening hundred years had considerably altered the fauna.

Hearty thanks were given to Mr. Lowndes on the President's invitation.

Major R. W. G. Hingston, M.C., gave his lecture entitled "In the Canopy of the Forest (British Guiana)," illustrated with numerous lantern-slides.

An outline was given of the methods adopted by the recent Oxford University British Guiana Expedition to explore the tropical rain-forest, the discussion of the scientific results being postponed until notes are properly put together and the specimens relating to them identified.

The party worked in a small area of forest on the right bank of the Essequibo River, about fifteen miles above Bartica. A brief description was given of the area of work, of the camp arrangements, and of the methods which the party found most suitable for collecting animals and plants. One of the chief objects of the expedition was to get into the canopy of the forest and to study at close quarters the life found to exist in it. Hitherto our knowledge of the canopy life consisted in what could be shot from it with a gun or observed in it with binoculars from the ground. It had never been examined at close quarters, and nothing was known of its insect fauna. A description was given of the appearance of this canopy and the methods adopted by the party in order to get stations established in it.

Ascents were made in four places. Access to the canopy was obtained either by rope ladders or by a seat that could be hoisted on a block-and-tackle. Observation posts were fixed in the canopy and rope ladders were spread in the branches, which permitted some freedom of movement in it. One post was placed in a tree at a height of twenty feet above the canopy, and this permitted the party to look down on the canopy and study it from above.

Collections of canopy-animals were made by scrambling about on ladders in the branches, by fixing traps at different levels, by placing baits such as vessels of water and pieces of carrion, by sweeping branches with a long net, by felling trees and collecting from the fallen branches.

Although results are not discussed at present, yet it may be said in a general way that the canopy of the tropical rain-forest abounds with animal life, that this life is altogether different from the life in the forest underneath, that collections of animals made in the canopy are bound to contain numbers of new species. The attempts made by the expedition were necessarily pioneer in nature, but they are capable of wide elaboration and extension, and there can be few areas which would better repay concentrated investigation.

From the collections made at different levels it is considered that a tropical forest should be regarded as consisting of strata of life spread out one above the other. It should be investigated not by just working on the forest-floor, nor even by combining the floor and the canopy. It should be examined in the same way as we explore the ocean, namely by investigating it systematically layer upon layer from the floor up to the roof. Such an investigation would add immensely to our knowledge, and is the only way in which we can get a true picture of the living constitution of the equatorial forests.

Mr. H. N. Ridley compared the Guiana rain-forest with that of the Malay Peninsula, pointing out the resemblance in the extreme humidity and the difficulties of collecting and preserving specimens there, and also the absence of wind on the ground-level, though there were air-currents which ascended through the trees, as illustrated by the dispersal of the small ground-orchid, *Didymoplexis*, the very light seeds of which were drifted up through the forest and spread on the upper winds to great distances. He also pointed out the greater height of the forest crown in the Malay Peninsula, the trees rising to a height of 150 to 180 feet, and the greater irregularity of the tops of the forest.

Mr. I. H. Burkill expressed his pleasure in learning that great attention had been paid to the stratification of the forest. Eastern rain-forests exhibit it. Tall trees with small leaves rise in cones and hummocks into the sunshine at the surface, and their means of dispersal is by wind. Below the surface larger-leaved trees come with fruits suited for dispersal by animals. This layer is deep. Below it in the eastern forests, which exceed in depth that described by Major Hingston, comes a layer where the light is so reduced that it can no longer support foliage, and a vault among the tree-trunks is produced. Below the vault, and made possible by the diffusion of light in it, comes the ground vegetation. The light-diffusion space could not be seen in any of Major Hingston's excellent lantern-slides, and would seem absent because the forest had not depth enough to produce it.

In eastern forests, at the ground, seed-dispersal is possible by feeding animals, and during rain-storms by water. This dispersal is through very short distances, and is the only dispersal which aids the phanerogamic herbs and undershrubs of the forest-floor. Their very restricted distribution results, for in the intense life of their habitat, cross-pollination from a flower which is not in close proximity must be extremely rare, and there is no mixing of stocks by the transport of the seeds to a distance.

Flower-pollinating insects will be found working in the forest, each in its stratum; and it is hoped that the results of the expedition may be adequate for tabulation. But the field is enormous, and the work of a few months but as a drop in the ocean.

Dr. J. M. Dalziel compared what had been said and shown of a tropical American rain-forest with those observed in the same latitude in West Africa. Previous descriptions of the former had seemed to indicate that its canopy was much more complete than that of the latter region, but Major Hingston's description and his illustrations showed that there was probably not much difference in aspect between the two; the vault was far from continuous, frequent gaps occurred, and in many places a considerable amount of light filtered through. The West African canopy had been observed in Liberia, Ivory Coast, Gold Coast, etc., but no detailed description existed, and though the general features were probably the same, there would be the differences in floristic composition to be expected in the two hemispheres. One physical condition, however, must be markedly different, viz. the effects of the sun's rays, for, as was evident from the views shown, the members of the expedition carried out their work, whether in the open or under cover, without sun-topees. This would be impossible in West Africa. The same condition had been observed in expeditions on the Amazon, where there was no need for the protection of a sun-helmet, indicating a profound difference in the effects on the human body, as experienced in West Africa, of certain sun-rays which might conceivably also have an influence on vegetation. Another point was that in the Amazon expeditions instantaneous photography seemed to be ineffective, even in the open, whereas in West Africa—apart, of course, from the gloom of the canopied forest—instantaneous photography presented no difficulty.

The President, in expressing the thanks of the meeting to Major Hingston for his very interesting account of his expedition, stated that as a representative of the Percy Sladen Trust he considered the results were highly satisfactory.

Major Hingston, in reply to questions, said that it was found unnecessary to protect either the head or neck from the sun's rays; that the light-intensity in the canopy was about 160 times greater than that on the ground: and that instantaneous photography was impossible. He also detailed how the tropical forest should be investigated in the future.

20th March, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 6th March, 1930, having been circulated, were taken as read and confirmed, subject to corrections in the scientific report which had been received by the Secretaries.

A list of names of those who have made gifts to the Library since the previous Meeting was read and laid on the table.

The following Fellows signed the Obligation in the book of the Charter and Bye-Laws and were admitted :—Phyllis Maude Taylor, George Fox Wilson, James Wyllie Gregor, and Francis Kingdon Ward.

Certificates of recommendation of the following candidates for Associateship were read for the second time in favour of John McConnell Black, Harold Stuart Thompson, and Benjamin Storrow.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time in favour of John Scott Thomson, George Simpson, and Robert Burgess. For the first time in favour of Mabel Annie McKenzie Drummond.

Mr. M. Burton showed a series of photographs of a fallen beech-tree, blown down in a recent gale. The bole was cracked along what appeared to be lines of torsion.

Dr. A. B. Rendle said that the explanation was probably the correct one, though it was obviously a question for the forester. Lines of torsion were well shown in conifers in Yellowstone National Park.

Miss R. F. Shove showed a hyacinth bulb which, although it had produced a small leaf in the normal position, had developed the inflorescence in a downward direction in place of roots.

The President suggested that a longitudinal section might show the relation of the different growing points.

Dr. C. Tate Regan read a paper on a new Ceratioid Fish (*Caulophryne* sp.), female with male, from off Madeira. The following is the author's abstract :—

The fish represents a new species of the genus *Caulophryne*, distinguished from *C. jordani* Goode & Bean by the greater number of dorsal and anal rays and by the filaments on the

stem of the illicium. Although distended by a recently-swallowed fish larger than itself, it took a bait, and was caught on a long line off Madeira. The specimen is a female, 210 (145+65) mm. long, with a dwarfed and parasitic male 21 (16+5) mm. long attached to her abdomen. It has been presented to the British Museum (Natural History) by Mr. R. England, British Vice-Consul in Madeira.

Professor R. R. Gates noted that the drawings exhibited by Dr. Regan showed each a single male parasitic on the female. Are there sometimes many males? and what is the greatest number observed?

The President said that it might not be generally known to all present that Dr. Regan's discovery two years ago of the parasitic male angler-fish was also the first observation of such parasitism among vertebrates, although very interesting cases had long been known among invertebrates.

Dr. Regan, in reply, explained that these fish are only obtained singly by some happy accident: they lead lonely lives at great depths in mid-ocean. This is the reason for their adoption of this strange sexual parasitism, but causes opportunities for observation to be rare. It is true that there are now perhaps sixty species recorded, but of the majority of these only one specimen is known. Of the males the slides exhibited showed all which have yet been seen in this country, being four cases of females bearing one male each and one female bearing two males; but a letter from Dr. Schmidt brought the intelligence that he has now a female bearing three parasitic males.

The President mentioned well-known similar cases among invertebrates, but he would submit that really the parasitic male of the angler-fish is unique. The nearest parallel is found among barnacles: but Darwin showed that the diminutive male has eaten and digested food in the normal manner during its free life, and that when attached to the female its genital products are formed at the expense of the tissues built up by the nourishment acquired in the previous phase; a truly parasitic male is not known except in the angler-fish.

The diminutive male of *Bonellia* (mentioned by Dr. Bidder) may be considered parasitic as probably deriving its nourishment from the secretions of the female. But it is a free-liver, and has no fusion of tissue with the female, nor does it levy a tax on her internal fluids. The nearest case that he knew of a relation similar to that between the male and female Ceratioid is the fœtus and the mother in placental mammalia.

Lt.-Col. J. Stephenson gave an account of his paper "On an Oligochæte worm parasitic in Frogs of the genus *Phrynomerus*," of which the following is an abstract:—

A specimen of a Nigerian frog, *Phrynomerus microps*, recently came under examination at the British Museum with a number of

small worms hanging out in a cluster of about a dozen from the anterior angle of each eye and from under the neighbouring part of the lower lid. Those at the angle came away with some difficulty or broke in the process of extraction; those further back came away easily. The concealed portion of the worm was in all cases the anterior end. The worms proved to belong to a new species of the genus *Nais* of the freshwater family Naididæ. Shortly after, Mr. Parker, who had handed over the former frog, found in a second species of the genus *Phrynomerus* (*bifasciatus*), from Beira, Portuguese East Africa, the Harderian (lacrymal) glands distended and transformed into a sac containing a number of small worms; these proved to belong to the same species as the preceding; none, however, were hanging outside. This discovery prompted the stripping of the mucous membrane from the roof of the mouth of the first frog, from Nigeria, when it was discovered that in it also the Harderian glands contained a number of the worms.

Oligochæta are rare as external, and still rarer as internal parasites. It is interesting to find the present worm in different species of the same genus of frogs thousands of miles apart.

The President, after expressing the thanks of the meeting, remarked on the unexpected and interesting character of Lt.-Col. Stephenson's observations. Although this parasitism of *Nais* in the regions surrounding the frog's eye had never been observed before, yet, when we hear that the same species of worm has been found parasitic on frogs 2000 miles apart from each other, it is impossible not to believe that further investigations will reveal many other instances. He asked whether any sexual stages had been found in the worms.

Dr. W. T. Calman asked if Lieut.-Col. Stephenson recognized no other case of parasitic Oligochæta. Was it a mistake to suppose that the pulmonary organs of certain freshwater snails were commonly occupied by a parasitic oligochæte?

Dr. Bidder said that the worms mentioned as commensal in sponges used a hundred years ago to fill a considerable part in discussions at the Linnean Society and Royal Society. John Ellis, in his famous letter to Solander*, objected to the previous statements that sponges were nests fabricated by the worms which lived in them, and stated that the sponge made its own currents in and out of holes which were not inhabited by worms. But Hogg in 1839† maintained to our Society that these currents are never visible in specimens destitute of parasitical animals, and that in the freshwater sponge they are caused by an insect (afterwards determined by his friend Dr. Westwood). But he affirmed that the freshwater sponge is a vegetable, and not formed by the insect which produces the currents.

* Phil. Trans. 1765, p. 284.
† Proc. Linn. Soc. i, p. 37.

Lieut.-Col. Stephenson said that he had found no sexual stages in the worms, but this was to be expected, as *Nais* reproduces almost entirely by asexual fission. It is true that the pulmonary cavities of certain freshwater snails are frequently filled with numbers of *Chætogaster*, but these were commensal, not parasitic.

The President added in regard to Dr. Bidder's remarks that the "worms" referred to by Ellis were those described by Peyssonnel*. He had had occasion to consult Peyssonnel's original papers, and had been bold enough to make the suggestion that the "worms" were without doubt the larvæ of Diptera,—in fact, maggots.

Capt. F. Kingdon Ward gave a lecture entitled "Botanical Exploration: Mishmi Hills, Assam," illustrated with numerous lantern-slides.

The flora of the Seinghku Di Chu, and Delei valleys, on the Burma–Assam–Tibet frontier, is most easily understood in relation to the rest of the flora of S.E. Asia. On the Percy Sladen Expeditions of 1926 and 1928 I explored some of the country between the Dihang–Brahmaputra and the Salween, at the sources of the Irrawaddy, and on the upper Lohit; this enabled me to connect up the flora of the eastern Himalaya with that of Yunnan, thus extending the observations made in Tibet in 1924.

South-eastern Asia is the meeting-ground of three floras whose exact boundaries are not known. These are, the central Asiatic region, occupying most of Tibet, Turkestan, and Mongolia; the eastern Asiatic region, China; and the Indo-Malayan region, occupying India, Malaya, and Indo-China. A glance at any physical map of Asia shows certain outstanding features in the south-east: (i.) The high plateau of Tibet. (ii.) The Himalayan ranges, which may be regarded as the escarpment between the agricultural plains of India and the pastoral plateau to the north. (iii.) The Burma–Yunnan ranges which form the escarpment between the tropical agricultural lands of Burma and the temperate agricultural plateau of W. China; this last slopes up rather rapidly in the north to the pastoral plateau.

Our knowledge of the facts of distribution is very incomplete. We know, however, that the fauna and flora of the Himalaya show affinity with those of Japan and Formosa on the one hand, and with those of Malaya and Java on the other. Some work has been done on the birds and mammals, and in recent years a good deal has been done on the flora, of these regions; but little is known of the distribution of the other vertebrates, or of the insects, as between these regions.

In order to account for the facts of distribution as revealed by exploration, it is necessary to trace the past history of S.E. Asia. Geological observations ought to give irrefutable evidence of the

* Phil. Trans. xlvii, p. 445 and l, p. 590.

sequence of events, but unfortunately geologists are not always agreed as to the interpretation of what they see; moreover, in the most critical areas little work has been done. It is here that the observations of the naturalist can supplement those of the geologist.

Two incidents in the history of S.E. Asia have particularly affected the distribution of animals and plants. These were (i.) the uplift of the Himalaya, and (ii.) the last glacial epoch.

The Himalayan uplifts took place in three phases between the late Eocene and early Miocene. Then comes a great lapse of time before the next important incident, and, unfortunately, we do not know what was going on all that time. According to J. W. Gregory, however, important events, some of which must have affected the distribution of fauna and flora, were certainly taking place. For example, an arid climate spread over much of the region in Pliocene times.

Then, in Pleistocene times came the great extension of the Himalayan ice; in recent times the ice has been everywhere retreating steadily.

At the time of the Himalayan uplifts the East Indian islands were either non-existent or very small. In late Miocene and early Pliocene times, that is, after the completion of the Himalaya and before the glacial epoch, they were united to the mainland of Asia, and remained so during the extension of the ice, which, it may be supposed, drove certain Himalayan species of birds, and certain Rhododendrons and other plants, including *Primula imperialis*, southwards to Java. After the glacial epoch —quite recently, in fact—Java became again separated from the mainland.

The uplift of the Himalaya had two consequences: (i.) It cut off Central Asia from the Indo-Malayan or Oriental region. (ii). It provided a bridge across Asia which stretched at least from Sikkim to Formosa. The glacial epoch, while it lasted, assisted greatly in the separation of these two floral regions. It also drove many species and genera southwards. But it had another effect. It sealed Central Asia. The poverty of the flora there is probably due more to a killing off of the flora by drought, followed by cold, than to the present conditions being too harsh. In south central Tibet I have found quite a rich alpine flora at 16,000–17,000 feet on the dry ranges far north of the Himalaya. The flora, which was probably killed off in central Asia, has hardly had time to get back over the passes, or to increase and spread where it was not entirely destroyed, since the ice retreated.

If the Himalayan uplifts did reach right across to the Pacific, there is an enormous breach in the wall where the big Tibetan rivers break through, and it becomes very difficult to follow the line east of the Dihang-Brahmaputra.

The high peaks which dominate mountain chains persist through the ages, and, if we can determine their heights and positions, we can plot the axis of the range on the map. In this way the

extension of the Himalayan axis can be traced eastwards to the neighbourhood of the Yang-tze, though its precise direction is uncertain, owing to the number of snow-peaks east of the Dihang, whose heights and positions are not known. By tracing the closely related groups of animals and plants across Asia, however, the naturalist can show how the line probably followed a certain direction, with almost as much certainty as the geologist who looks for folds of the right age and type.

Besides the broad facts of distribution already referred to, the more detailed points to which it is necessary to draw attention are the following:—

(i.) If the Himalayan uplift were continued eastwards to the Pacific, there should still be at least some influence as a barrier, as well as of its effects as a highway, since it has only become breached in quite recent times. There is plenty of evidence for this. In fact, the line separating the Eastern Asiatic from the Indo-Malayan floral region in southern China is probably the line of the Himalayan uplift. There is also evidence of an east-to-west barrier in the region where it might perhaps be least expected, namely, in the great breach of the five rivers. Thus far, at any rate, biological evidence supports geological evidence.

(ii.) The dual nature of the Himalayan alpine and sub-alpine flora. The one is Sino-Himalayan, the other Indo-Himalayan. Possibly the one may eventually be traced in the direction of Japan and Formosa, the other in the direction of Java—the two meeting on opposite flanks of the Himalaya.

Amongst many interesting facts of distribution discovered, attention may be drawn especially to the following:—The presence of *Primula Wattii*, *Rhododendron pumilum*, and *Nomocharis nana* in far northern Burma—an eastern extension of Himalayan species; and of *Bryocarpum himalaiense*, *Rhododendron Griffithianum*, and *Meconopsis paniculata* (hitherto known only from Sikkim and Nepal) in eastern Assam. The presence of *Trollius Farreri*, *Podophyllum versipelle*, *Nomocharis aperta*, *Primula septemloba*, *Saurauja subspinosa*, *Viola pogonantha*, *Polygala Mariesii*, all Chinese plants, in upper Assam.

Further, the discovery of two new species of wingless Grasshoppers, of the genus *Podesina*, has shown that it is this genus of N.E. Asia and Japan, and not the unrelated genus *Conophyma* of the Pamirs and western Himalaya, which is represented in the eastern Himalaya.

Mr. I. H. Burkill claimed that from out of the interesting matter which had been put before the Society a special importance should be attached (1) to the climatic divide near Rima, where the cloudy conditions end, and with them forests, and (2) to the limit of Conifers (other than *Podocarpus*) towards the Plains. He said that it is desirable to trace these limits on phyto-geographic maps.

He suggested, as a theory worth examining, that white ants have played a part in determining the present distribution of the Coniferæ.

Major Hingston expressed his interest on what had been stated about geographical distribution. He remarked that on crossing the Himalaya and stepping out on the great plateau to the north it seemed as if one was entering into a new world. Not only were the geographical features quite different, but on every side were animals and plants altogether dissimilar from those seen on the southern slopes of the ranges. The fauna of the northern Himalayan system seems to be much more like that of the Arctic than that of the opposite side of the mountains. Captain Kingdon Ward pointed out the importance of the glacial period as a factor in explaining the present distribution. And there is certainly on the great plateau to the north of the Himalaya evidence on every side and in every valley—tiers of moraines, perched blocks, erratic boulders—that the whole of this region at no very distant period must have been covered almost completely in ice.

Dr. J. M. Cowan remarked upon the resemblance of the vegetation described to that of the Sikkim Himalayas, and expressed his pleasure in the excellent photographs which were shown, especially one of *Magnolia globosa*, a tree which is also found near Tonglu on the Singalila Range, Darjeeling. It is known to the Nepalese as *Kokra Chanp*, the Hen's Magnolia, on account of its large white flower bud, which resembles a large egg, and, in the month of May, makes this tree one of the most striking in the forest. He asked Capt. Kingdon Ward upon what grounds he based his opinion that the heavy growth of moss was responsible for the death of many trees at elevations of 8000–12,000 feet. Oaks, for example, in the Darjeeling forests generally lived to an age of at least 150 years, and, although often hollow, seemed little affected by the moss.

Capt. Ward, in reply, said that he found large quantities of moss on the needles and branches of fallen conifers, and was of opinion that it interfered with the function of the needles sufficiently to kill them.

After the President had thanked the lecturer, Mr. Gilbert Rogers asked to be allowed to say a few words on the subject of the effect of moss on trees. In the high level coniferous forests of the Himalayas it did contribute to their death. He then described how, in the hot weather (April or May) of 1890, when Forest Officer in charge of the Darjeeling Forest Division, he had to put out a forest fire which had crossed the Singalila Range of mountains from Nepal, between Sandakphu and Phalut, at an elevation of about 12,000 feet, and entered a forest of the Himalayan Silver Fir (*Abies Webbiana*). The fir-forest was over-mature, and many of the trees were unsound. Both stems and branches were much infested with moss, which at that time of the year was very dry. The fire set alight the moss on

the lower part of the stems of the trees and ran up the stems into the crowns of the trees. The wind blew the burning pieces of moss from the crown of one tree to that of another, and a considerable number of trees were killed before the fire was extinguished.

The moss, of itself, did little or no damage to the trees under normal conditions, and is, in his opinion, only a proof of the great amount of moisture in the air during the greater part of the year, and especially during the monsoon, when the forests are almost always enveloped in the clouds, which at that time of the year are saturated with water vapour.

3rd April, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday the 20th March, 1930, having been circulated, were taken as read and confirmed, subject to corrections in the scientific report which had been received by the Secretaries.

A list of names of those who had made gifts to the Library since the previous Meeting was read and laid on the table.

The President referred to the exhibit of a drawing of Black Notley Church, showing the tomb of John Ray. The drawing was made by Edward Forbes the zoologist, and had just been received from Dr. Owen Lankester, to whom the thanks of the Society were accorded for this interesting gift.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of Mabel Annie McKenzie Drummond. For the first time in favour of Cedric Errol Carr.

The following candidates were balloted for and elected Associates:—John McConnell Black, Harold Stuart Thompson, and Benjamin Storrow.

In accordance with Chap. X, Sect. VII of the Bye-Laws, the following Fellows were elected, by show of hands, as Auditors of the Treasurer's Accounts for 1929–30:—

Representing the Council: Mr. I. H. Burkill.
Mr. Francis Druce.

Representing the Fellows: Dr. W. T. Calman.
Mr. D. J. Scourfield.

Capt. F. Kingdon Ward, referring to the exhibit by Mr. M. Burton at the last meeting of the Society, showed a photograph taken in Tibet of a pine tree with its bole twisted in a corkscrew-like manner.

Mr. H. Lister (Visitor) gave an account, illustrated with lantern-slides, of his observations on the comparative morphology of the protozoan fauna, found in the paunch and reticulum of ruminants.

Such protozoa have been investigated by numerous workers. The actual species vary with the geographical environment of the host. Previous attempts to cultivate these protozoa have been relatively unsuccessful. By using suitable culture media and a specially designed microculture incubator they have, during the present investigation, been kept alive for longer periods than hitherto. The cultures have shown that the bacteria inevitably introduced with the protozoa render the medium acid, and that this proves fatal to them.

The work of R. G. Sharp called attention to the occurrence in these ciliates of a system of fibrils, termed by him the neuromotor system, this controlling the action of the cilia. Structures of a similar character have been demonstrated in numbers of the Isotricha.

Sharp also showed that several so-called species of *Diplodinium* were really morphological variants of one basic type,—*D. ecaudatum*. This work has been confirmed and extended to two series of forms with *D. burra* and *Entodinium bursa* as their basic types.

The President regretted that there was so little time available for discussion of the many interesting questions provoked by this paper. Firstly, there was the difficulty of surmising the nature of the circumstances or conditions which limit a particular parasite to a particular host. Then there was the remarkably high development, in the protozoa figured, of what he must call the "alimentary canal." Why was this? Had Mr. Lister any observations of the nature of the food taken? and does this necessitate in any way such high development? A puzzling thing in this connection is that, of two abundant parasites in the common frog, one is a ciliate with highly developed alimentary canal, and the other is *Opalina*, in which no rudiment is traceable of such an organisation.

After thanks had been given for the paper, Mr. Lister replied to the President that the food-material of these protozoa consisted almost entirely of bacteria, but occasionally inclusions of vegetable tissue could be recognized by their cell-walls; sometimes the spiral thickening of a tracheid would be seen, everything except the thickening having been dissolved.

Professor H. S. Holden summarised his paper on "Some

wound reactions in *Ankyropteris corrugata*," which was illustrated with lantern-slides. The following is the Author's abstract :—

The tissues of the fossil fern *Ankyropteris corrugata* show well-defined wound reactions. In the root these consist of irregularly disposed wedges of meristem and are confined to the cortex. In the stem wounds usually take the form of irregular cortical fissures bordered on either side by a strip of meristem. In the petiole, where the wound is superficial, a pad of healing meristem is developed, but, where it is deep-seated, the vascular tissues may be involved. The reaction in such cases takes the form of the development of secondary tracheids, which are usually short and of small calibre. There is some evidence that the phloem or phloem parenchyma may also become meristematic under these conditions.

Dr. D. H. Scott spoke of the great interest there was in the genus *Ankyropteris*, which was first described by Williamson and which had recently been so thoroughly worked out by Professor Holden. Wound reactions were sometimes very puzzling in fossil plants; he well remembered having what he at first thought was a new species of *Lyginodendron*, but which proved to be a *Heterangium*, which showed wound reactions. The close resemblance shown between *Myriophyllum* and fossil forms as seen in one of the lecturer's slides was striking. He asked whether tyloses, recorded by Williamson, were commonly seen.

Professor Holden, in reply, said that the cells of *Ankyropteris* appeared to have bulged on the slightest provocation; it appeared that much of this was post-functional, occurring when the plants were in an effete condition.

Dr. J. M. Cowan gave a lantern-lecture entitled "Botanical Exploration through North-West Persia."

The lecturer gave a brief survey of the vegetation of Iraq and North-West Persia observed on a tour made on behalf of the John Innes Horticultural Institution and Kew Gardens. The route followed was from Damascus across the Syrian Desert to Baghdad, thence to Khaniqin, Kermanshah, Hamadan, and Isfahan; then northwards through Teheran and Tabriz to Astara on the Caspian Sea, and also to Urumia and the frontier mountain ranges beyond the Plains of Mergavar and Tergavar.

Mr. Gilliat-Smith and Dr. O. Stapf contributed to the discussion of the lecture.

1st May, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 3rd April, 1930, having been circulated, were taken as read

and confirmed, subject to corrections in the scientific report which had been received by the Secretaries.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—Canon Henry Kingsmill Moore, Frank William Jane, and The Marquess of Headfort.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time, in favour of Cedric Errol Carr. For the first time, in favour of Ivor Vickery Newman, Basil Harrington Soulsby, and George Arthur Nelson.

The PRESIDENT announced that the Council had unanimously resolved to award the Linnean Gold Medal to Professor James Peter Hill, F.R.S.; also, that the Trail Award and Medal for 1930 will be made to Dr. Kathleen Bever Blackburn, F.L.S.

The BOTANICAL SECRETARY showed some Fritillaries (*Fritillaria Meleagris*) sent by Mr. S. J. Batchelder, F.L.S., from Stowmarket, Suffolk, where apparently it is known as the wild tulip.

The President asked whether the plant was known previously from Suffolk.

Mr. R. Paulson said that until the ground was enclosed *Fritillaria* was still to be found in the locality given in Trimen & Dyer's 'Flora of Middlesex.'

Miss G. Lister said she had gathered Fritillaries at Totteridge, Herts.

Mr. Ramsbottom, in reply, said that the plant was much more widely distributed than was usually thought. There were two collections from Suffolk in the British Museum, one of which was in Ed. Forster's Herbarium.

Mr. E. B. WORTHINGTON gave an illustrated account, entitled "Vertical movements of Fresh-water Macroplankton."

The most thorough observations on the vertical distribution of plankton have been made on the plankton of the English Channel by F. S. Russell, using horizontally-towed plankton-nets. It was with a view to testing whether Russell's conclusions with regard to the vertical migrations of marine plankton can be applied also to fresh water that the work here discussed was started. A method was devised, using a vertically-hauled closing plankton-net, and the changes in the vertical distribution of the Crustacea were traced for periods of 24 hours or more in the

Victoria Nyanza and in Lake Lucerne. The advantage of vertical hauls over horizontal hauls for fresh-water work lies in the facts that the position of fishing is constant, the exact depth of fishing is known, and series of hauls from bottom to surface can be repeated at frequent intervals. This enables the movements of the plankton to be traced from hour to hour and correlated with the amount of light and other physical conditions. The error due to swarming of the individuals, which has been found serious by some workers, was not sufficient to invalidate these results.

The best results are from a cloudless 26 hours on L. Lucerne: the total depth (105 metres) was divided into stages as follows:— bottom to 75 metres, 75 to 50, 50 to 40, 40 to 30, 30 to 20, 20 to 10, 10 to 5, 5 to surface. This series of hauls was repeated at hourly intervals, and after counting the catches the vertical distribution of each species every hour was plotted. Most species start their descent at dawn, and reach their lowest level (50 to 60 metres) before the sun attains its zenith. Then a slow upward movement starts, accelerates at dusk, and continues for two or three hours after complete darkness. There is a difference between the behaviour of young and old individuals of certain species, showing that in growing up the individuals become less susceptible to light, and so can remain longer at the surface. In the case of *Bosmina coregoni* the young migrate on the average from 7 metres to 55 metres, but the adults remain near the surface day and night, showing that they have acquired complete powers of accommodation to changing light intensity. By plotting the migration of the average individual the extent of migration and the speed of descent and ascent for each species has been calculated as follows:—

	Extent of migration.	Speed of descent. 1 metre in	Speed of ascent.	
			Noon till dusk. 1 metre in	Dusk onward. 1 metre in
Daphnia longispina, adults	10–40 metres.	5 minutes.	25 minutes.	6·3 minutes.
Daphnia longispina, young	5–60	3·1	17·5	4·3
Bosmina coregoni, adults	15–15	no movement.		
Bosmina coregoni, young	7–55	4·5	26	7·5
Diaphanosoma brachyurum	3–10	10	no movement.	12
Diaptomus gracilis, adults	13–30	12	60	15
Diaptomus gracilis, young	20–37	20	60	12
Diaptomus laciniatus, adults	25–75 (?)	4·6	14 (?)	8
Diaptomus laciniatus, young	22–58	4·4	28	8
Cyclops strenuus, young	12–46	7	60	5·5
Cyclops leuckarti, adults	3–15	20	105	12

The results will not fall in altogether with Russell's conclusion that each species has an optimum degree of illumination, in which

it will stay when possible and to which it will migrate, because (1) the descent is finished well before the sun attains its zenith; (2) the main upward movement does not start till dusk, and continues for several hours after complete darkness; (3) there is very little tendency to a random distribution during the later hours of darkness. An alternative hypothesis is suggested, depending on the simple interaction of geotropism and heliotropism. The organisms may be regarded as being under the influence of two forces: (1) a negative geotropism, acting persistently from below and causing them to congregate in the upper layers, and (2) a negative heliotropism, acting intermittently from above and causing those species which are susceptible to light to descend during the day. Light forces them down into the lower layers during the morning; after midday they are free to move upward slowly; but it is not until dusk that negative geotropism has full sway and the organisms start their main upward movement. Most species are filter-feeders, dependent on the nannoplankton, which is most abundant in the upper layers; it is suggested, therefore, that hunger is the ulterior reason why they should seek the upper layers. Thus those species which are less susceptible to light, such as the adults of *Bosmina* and *Diaphanosoma*, have an advantage in that they can spend much more of their time in their food regions.

Dr. G. P. Bidder remarked that from the graphs just shown the plankton seemed to have travelled upwards in the evening 30 metres in 1½ hours—a metre in three minutes, or half a centimetre a second. This seems good going for such small creatures; is it Mr. Worthington's view that at the onset of darkness they start swimming upwards as hard as they can and go on until they reach the top?

Dr. W. A. Cunnington enquired if the speaker had any experience with Ostracoda paralleling that of Prof. Sars, who found them at night with the surface tow-net, bottom forms coming to the surface.

The President, in inviting thanks to Mr. Worthington, pointed out that the study of plankton had become in these days much more of an exact science, and a science whose importance is generally recognized. On the distribution of plankton the movement and welfare of all other marine animals are dependent.

Mr. Worthington said that Dr. Bidder had correctly expressed his views. The graphs only represented the movements of the centre of gravity of the plankton,—many individuals would move much faster. The movement seems to be due to the strange circumstance that all animals have not yet adapted themselves to light. In reply to Dr. Cunnington, he found Ostracods only by night in Lake Victoria.

Dr. G. P. Bidder read his paper entitled "On the attitude of a Hexactinellid at the bottom of the sea, as compared with that

assumed in museum jars and monographs," of which the following is an abstract:—

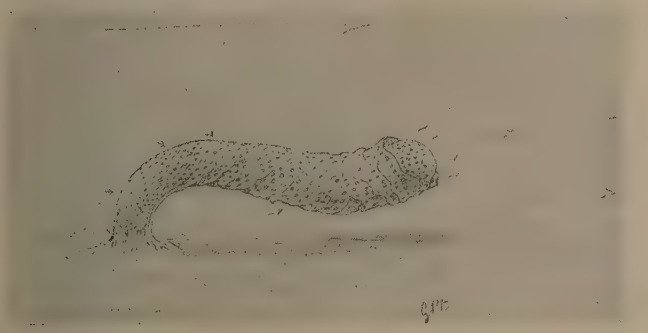
Glass-sponges (Hexactinellida) have never been seen in the great depths which form their natural habitat. They are known only from specimens torn up from the bottom of the ocean, pictures of glass-sponges *in situ* as well as the mounting of museum specimens being alike arranged according to the fancy of the artist. This fancy has, very naturally, represented them with the centres of gravity vertically over the bases, a position which satisfies eyes accustomed to see trees and shrubs growing. Close examination generally shows, however, that when the specimen includes the extreme base of the sponge, the assumption of a vertical position for the general axis of the sponge involves the conclusion that the surface of attachment was inclined steeply to the horizontal. The attachment very frequently is effected by a brush of spun-glass-like spicules anchored in the mud, and it seems unlikely that there should be many steeply inclined mud-slopes at the bottom of the deep sea.

If, however, the representation of the living sponge be orientated by making the surface of attachment horizontal, as in text-fig. 1, a very interesting and instructive picture is obtained, at once intelligible if we remember that along most of the deep bottoms of the ocean a cold slow current from polar to tropical regions is passing unceasingly. I have elsewhere (Q. J. M. S. lxvii, p. 312) put forward the view that the Hexactinellida show no hydraulic efficiency in their canal-system, because they have merely to stretch their nets across the bottom-current of the deep ocean and a continuous supply of water streams through them eternally. In the text-figure we see a drawing of *Euplectella*, modified from Schulze's well-known picture ('Challenger' Reports, xxi, pl. i) by making the surface of attachment horizontal; it is seen that if the vent and sieve-plate lie down-stream, the effect of the current will be to draw water out from the vent and in through the perforations on the walls of the tube. This is true while the walls of the lateral perforations are flush with the general surface of the tube, but if, as in *Farrea occa*, the interior of the tube communicates with the exterior through perforations terminating lateral branches or prominences, then, if the prominences be sufficiently bulky to obstruct the current, so that it flows faster across the lateral apertures than elsewhere, the pressure will be therefore lower in this position and the water will be sucked out from the cloaca by these lateral apertures as well as by the terminal vent *.

* In the statements above as to water entering the cloaca by the flush apertures of *Euplectella* and leaving the cloaca by the prominent apertures of *Farrea*, I have had the advantage of confirmation from an eminent authority on the flow of water. In the next paragraph it is possible that the greater growth of the tissues breasting the stream is merely due to the reception of more food, but some facts in ontogeny favour the view given here.

The dermal tissue of sponges is sensitive to the movement of water over its surface, as shown by the contraction of vents under "Parker's reaction" (Q. J. M. S. lxvii, p. 314); the tissues observed contracting when the current over them ceased or diminished. If we assume that in growing sponges growth is more rapid on the side against which the current impinges, we can explain the anomalies of spoon-like and fan-like forms in the same species of Clionid or Axinellid sponges in which cup-like forms are found, the cup-like form showing a compassing tide and the fan a constant current. A similar reaction in a sponge of fixedly tubular shape would cause the side of the tube towards the current to grow longer than the sheltered side, so that the sponge would bend until the axis of the tube lay down-stream and all sides were acted upon equally.

Text-fig. 1.



Euplectella aspergillum.

Mr. M. Burton described the question of the flow of water in the canal-system of Hexactinellida as mysterious, and consequently he did not feel able to express either agreement or dissent with the views just advanced.

Dr. W. T. Calman found himself less hampered by knowledge than Mr. Burton, and able to express, on the one hand, the admiration which they all felt for the very fertile imagination of the Zoological Secretary, and, on the other, the most profound distrust in its results. The marked sigmoid curve of the well-known illustration of *Euplectella* is not found in the majority of specimens nor in those exhibited on the table; the complicated bush of *Farrea occa* on the table differed much from the simplified diagram on the screen, and would defy the most eminent mathematician who wished to calculate the pressures of the current winding among its branches. Parker's reaction was not observed in Hexactinellida; Dr. Bidder had informed the Society that Hexactinellida were a different phylum to the rest of the sponges:

what reason is there, then, to believe that their tissues react in the same way?

Dr. Bidder pointed out that the specimens of *Euplectella* on the table had the basal extremity truncated; even so, two out of the three showed a distinct curve. The specimen of *Farrea occa* shows its relation to the diagram when the upper side is placed uppermost.

Mr. Burton quoted observations by de Laubenfels in America of the marked influence on the form of sponges of differing exposure to waves.

The President considered that they owed their thanks to Dr. Bidder for calling attention to the relations between currents and the form of organisms. In colonial Polyzoa there are many forms taken by the colonies which suggest a utilization of the current such as Dr. Bidder had postulated for the Hexactinellida. He would like, however, to ask Dr. Bidder why, since the hexactinellids had collar-cells, these were not responsible for the flow from the vent, as in other sponges?

Dr. Bidder replied that in other sponges the cloaca is a pressure-chamber, from which the efferent jet spurts out through the vent, the pressure in the chamber being kept up by the collar-cells. This is clearly not the case in *Euplectella*, since the walls of the cloaca have innumerable perforations giving direct communication between interior and exterior without passing through the layer of collar-cells.

Mr. M. Burton (Visitor) gave a lecture of Glass-Sponges, which was illustrated by the epidiascope, lantern-slides, and exhibits.

The lecturer suggested that the scientific history of sponges could be resolved into three phases. The first, prior to 1842, during which opinion was divided whether they were plant or animal. The second, from 1842 until recent years, when they were regarded quite definitely as animals, but opinion was divided whether they were specialised Protozoa or degenerate Cœlenterata, or whether they constituted a separate phylum, or even sub-kingdom. The third was marked by Dr. Bidder's proposal last year to revive the idea of treating them as a sub-kingdom, the Parazoa. This sub-kingdom he divided into two phyla, the Nuda and the Gelatinosa, the former to include the Hexactinellida only, the latter the rest of the sponges. This recognition of the great gulf between the Hexactinellida and other sponges, and between sponges and the rest of the Animal Kingdom is two-fold. In the first place it counteracts the tendency to make too close a comparison between the Hexactinellida and other sponges, and in the second place lays stress on the undesirability of seeking to homologise the structure of sponges with that of the Metazoa, from which so many erroneous ideas, and, particularly, so much misleading terminology, have arisen in the past.

The President asked the audience to give their thanks to Mr. Burton for a lecture which he was sure had been greatly

enjoyed. He had been reminded by Mr. Burton's historical summary that England in the early days produced many who staunchly advocated the animal nature of sponges, foremost of them being John Ellis in the eighteenth century, who described the sponges as throwing out and sucking in water. He invited remarks from Dr. Bidder.

Dr. Bidder expressed the extreme gratification he had received from Mr. Burton's approval of his suggestions as to classification, an approval very kindly expressed and valuable from the wide and thorough knowledge which Mr. Burton possessed in so many groups of sponges. There were many things in the lecture which had attracted his interest, but the hour prevented comment.

During the Meeting there was a successful trial of an Epidiascope, which it was intended to purchase for the Society.

15th May, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 1st May, 1930, having been circulated, were taken as read and confirmed, subject to corrections in the scientific report which had been received by the Secretaries.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-Laws and was admitted:—James Herbert Orton.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time, in favour of Ivor Vickery Newman, Basil Harrington Soulsby, and George Arthur Nelson. For the first time, in favour of Charles Horton Bestow.

The following candidates were balloted for and elected as Fellows:—John Scott Thomson, George Simpson, Robert Burgess, M.Sc., Mrs. Mabel Annie McKenzie Drummond, B.Sc., and Cedric Errol Carr.

Mr. H. R. Hewer read his paper "Studies in Colour-Changes in Fish. Part V. The Colour-patterns in certain Flat-fish, and their relation to the environment." (Communicated by Prof. E. W. MacBride, F.R.S.)

All the evidence which has been brought forward by many different investigators goes to show that the flat-fish possess, to a high degree of efficiency, the power to alter their colour and appearance in accordance with stimuli received from the background. In reviewing the literature it appeared to the author that the limiting factor of this power of adaptation was the variety of colour-patterns possessed by any particular fish. Within these limits, however, the fish displayed considerable ability to conform to the colour and texture of their surroundings. It therefore seemed justifiable to assume that the changes of colour observed under laboratory conditions were used for a similar purpose in natural surroundings; and, having regard to the complexity of the changes, that they were of importance in the natural economy of the fish. If this were so, then a fair degree of correspondence between the appearance of the fish and the character of the background of the normal habitat could be expected.

Microscopical examination of the chromatophores, which form the basis of the colour-patterns, has brought to light some very interesting facts. First, the spots occurring on the upper side of the body may be divided up into groups according to their characters, such as distribution, size and constituent chromatophores. These groups constitute the "patterns," such as the "Orange and Black Spots," the "White Spots" and the "Dark Patches." They appear to act as distinct entities, all the spots belonging to any particular pattern reacting in the same manner to any one stimulus. The constitution of any given type of spot is remarkably constant within a species, but is subject to considerable variation from species to species. Thus it becomes clear that a given pattern, while conforming in distribution over the surface of the fish and in certain fundamental facts of constitution to the accepted type for that pattern, is modified from species to species; and these modifications appear, in all cases where the data regarding the habitats are sufficiently full, to be adaptative. Outstanding examples of this are the Sand Dab (*Pleuronectes limanda*), the Flounder (*P. flessus*), the Common Topknot (*Zeugopterus punctatus*), and the Scald-back (*Arnoglossus laterna*). Further, among the fish examined, those having the greatest number and complexity of colour-patterns and therefore possessing the machinery for the largest range of adaptation, are the Turbot (*Rhombus maximus*) and the Brill (*R. lævis*). These two fish are noted for their habit of moving over considerable areas and so passing over many different kinds of background.

Moreover, it has been found that the distribution of the spots forming several of the patterns is so constant over many species that a generalised type can be drawn up for almost the whole group Heterosomata. The exceptions to this scheme are the Soles and *Psettodes*. The latter, however, is so primitive that it suggests the origin of certain of the patterns found in other flat-fish. Its coloration appears to be more easily related to that of vertically

swimming fish than to those horizontally disposed forms living in close contact with a mottled or broken background.

A study of the constitution of the spots in young forms in closely related species has demonstrated a series of stages of complexity approximating to the lines along which evolution has probably taken place.

Mr. J. T. Cunningham gave his congratulations to Mr. Hewer on his contribution on a very difficult subject. He could not agree as to the value in relation to protective resemblance of specific markings; the paper did not prove that the protection in one species was greater than in another on the same ground, and no experiments had been made to test the point. He himself was not convinced that specific differences are adaptive, nor was he completely convinced of the adaptive value of the patterns described by Mr. Hewer. Is there evidence that the red spots of plaice, on its proper ground, are more efficient for concealment than the yellow spots of dabs? In regard to the transverse stripes of the little-known *Psettodes*, he was surprised to hear no reference to the transverse stripes on the very common *Solea variegata*, well-known at Plymouth as the Thickback. Do *epidermal* chromatophores really exist? In the frog certainly they are all dermal; their processes may lie among the epidermal cells, but the body of the chromatophore is below.

Dr. Remington Kellogg (Visitor) pointed out that fish preserved in alcohol had usually been killed in a state of alarm, therefore the transverse bands on the museum specimens of *Psettodes* probably represent its alarm-coloration.

Dr. J. H. Orton said that the slight amount of information which Mr. Hewer had been able to add showed how little we know as yet of the whole subject. We do not know how far the patterns really agree with the natural backgrounds, and we do not know whether the fish are always on the same bottoms. Probably the pattern of the species represents a sort of mean of the patterns of the backgrounds on which it lives. At Plymouth the Topknot—also a banded fish—is found on the under-side of stones, and often cannot be distinguished from them except by touch; the stones in question are greyish, with *Spirorbis* growing on them, and with darkish streaks.

Professor E. W. MacBride found the criticisms of the paper fair. It is unfortunately true that science does not enable us to see the colour-pattern of the bottom of the sea. That the sedentary stillness of a fish in an aquarium does not prove perpetual inactivity may be seen by anyone who will take a sudden glimpse of an aquarium at night. The change of colour with changing backgrounds has been proved in various animals to be a real imitation, because it ceases when the optic nerve is cut. He was interested not only because the earlier part of the work for this paper was done in his laboratory, but because Mr. Hewer had read a most interesting paper.

The President conveyed the thanks of the Meeting to Mr. Hewer, and invited his reply to the questions which had been asked.

Mr. Hewer replied to Mr. Cunningham that he was convinced of the specific value of the pattern; if a microscopic preparation of a black-and-red spot were shown him he would undertake to name the species. Undoubtedly there are epidermal chromatophores; in a black spot there are about three dermal chromatophores to each epidermal chromatophore, seen in section clearly completely above them. He agreed with Dr. Kellogg's suggestion that the *Psettodes* showed an alarm pattern. It is quite true that the actual habitat as regards background is in most cases unknown; his only suggestion for the red spots of plaice was based on the description by Mr. Borley of the breeding-ground of plaice in the North Sea, with brown sand and fragments of shells, particularly *Tellina*, *Solen*, and *Donax*, this seemed a background fairly imitated by the plaice.

Dr. E. M. Delf gave an account of the release of the oogonia in the Fucaceæ.

The first species considered was *Bifurcaria brassiciformis*, one of the Fucaceæ common on the shores of the Cape Peninsula. Comparison was then made with other genera of intertidal habitats such as *Fucus*, which is habitually exposed during the fall of the tide, and *Sargassum* and *Cystophyllum*, which are intertidal but constantly covered even at low spring tides in most localities.

Attention was drawn to the limited nature of our knowledge in this connection, and to the need of further observations on the shore both as regards habitat, periodicity, and manner of emission.

Mr. G. Tandy said that on Low Isles, a reef of the Australian Great Barrier system, there is a *Sargassum* which is exposed in the daytime at low water spring tides round the Winter solstice (S. Hemisphere). It has not yet been observed in a mature reproductive state.

Cystophyllum muricatum is a species of sheltered water, and though rarely exposed is subject to great rise of temperature at the time of low water. No generalization is, as yet, possible.

Mr. J. Ramsbottom remarked on the interest of Dr. Delf's communication. The study of seaweeds had shown several intensive periods in the history of British botany, and it looked as if such a period was developing at present. The programme that evening suggested a liaison between zoologists and botanists interested in marine problems.

The President, in thanking Dr. Delf, asked about reproduction in the Gulfweed (*Sargassum*).

Mr. Tandy supplied the information that the Gulfweed is sterile.

The President announced that at the Anniversary Meeting on Saturday, May 24th, his Address would give some further account of Whales and Whale-fishing in the Southern Hemisphere.

ANNIVERSARY MEETING.

24th May, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 15th May, 1930, having been circulated, were taken as read and confirmed, subject to corrections in the scientific report which had been received by the Secretaries.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

A certificate of recommendation of the following candidate for Fellowship was read:—For the second time, in favour of Charles Horton Bestow.

The following candidates were balloted for and elected as Fellows:—Ivor Vickery Newman, Basil Harrington Soulsby, and George Arthur Nelson.

The Treasurer presented his Financial Report and the Accounts of the Society, duly audited, for the year 1929–30. On a motion by Dr. A. B. Rendle, F.R.S., seconded by Dr. W. T. Calman, F.R.S., the Report and Statement of Accounts were adopted.

The Bye-Laws regulating the Election of Council and Officers having been read by the Assistant Secretary, the President declared the Ballot for Council and Officers to be open, and voting began. The Ballot for Council was closed at 5.30 p.m. and for Officers at 6.0 p.m.

Meanwhile the Librarian and Assistant-Secretary presented his Report as follows:—

MEETINGS.—During the Session of 1929–30 there were held thirteen General or scientific Meetings, excluding the Anniversary Meeting. The Council met eleven times, and Library Committee five times.

PAPERS.—At the thirteen General Meetings forty-three communications were presented, twenty-two of which were purely or predominantly zoological (14 papers, 3 lectures, 3 exhibits, 2 discussions), and twenty-one purely or predominantly botanical (7 papers, 5 lectures, 9 exhibits).

LIST OF THE SOCIETY.—Since the last Anniversary Meeting, the Society has lost thirty-eight members. The detailed statement is as follows :—

19 Fellows by death :—William Richard Carles, Charles Chilton, Walter Gill, John Harrison, George Henderson, Augustine Henry, Upendranath Kanjilal, Sir Edwin Ray Lankester, James Cosmo Melvill, William Narramore, David Paul, Charles Edward Pearson, Oswald Alan Reade, Wilfrid Robinson, Charles Coltman-Rogers, Charles Edgar Salmon, Martin Hubert Foquet Sutton, Harold Wager, Sir George Watt.

1 Associate by death :—Miss Alice Pegler.

14 Fellows by Withdrawal:—John Humphrey Barbour, Edward Battiscombe, Charles Edward Jones, Donald McDonald, Charles Francis Ullathorne Meek, Victor Armsby Putterill, Robert Ray, James Chapman Shenstone, Arthur Francis Bulmer Standfast, Francis James Stayner, Khubchand Isardas Thadani, Margaret Tribe, Isabel Turnadge, Hugh Whistler.

4 Fellows by Removal:—Harry Bertram Harding, Thomas Robertson Sim, Bertram Hanmer Symons-Jeune, Harold Wilkinson.

During the Session and including the Anniversary Meeting, 3 Associates and 35 Fellows have been elected. Of the 35 Fellows, 30 have qualified.

The present number on the List of Fellows is 781, with 9 Fellows elected but not yet qualified.

LIBRARY.—The direct expenditure on the Library from the 1st May, 1929, to the 30th April, 1930, was £702 10*s.* 8*d.*, including the first half of the third third, amounting to £333 6*s.* 8*d.*, of the grant from the Carnegie United Kingdom Trustees. The reason for this restricted expenditure as compared with that of last year has been the desire to ascertain very thoroughly which are the best books on which to spend the last portion of the Carnegie grant.

The usual routine work of the Library has been carried on, and, in addition, Mr. A. W. Sheppard has given his valuable services in cataloguing the additions for the past year, and in other ways. Mr. J. Robson, another volunteer, has been

working on an author-list of papers in the Society's publications. In another direction, work is still in progress in making more available the Society's collection of pamphlets and separate copies, and in this connection the staff has had the help and advice of two members of the Library Committee—Dr. R. T. Gunther and Dr. T. A. Sprague.

A beginning has been made in converting a portion of the rooms on the second floor into a library extension. Steps have been taken to obtain a supply of suitable shelving in one of these upper rooms, arranged in such a manner as to give accommodation for about 6000 books. This should give considerable relief to many of our overcrowded shelves in the main Library.

During the year 44 works have been purchased and 120 books and pamphlets presented, making a total of 164 additions. This number does not include current periodicals, of which the Society receives between 600 and 700.

Between the 1st May, 1929, and the 30th April, 1930, 1116 volumes were borrowed by 168 Fellows and Associates. In addition the Central Library for Students borrowed 136 volumes—double the number borrowed last year. The Society borrowed on behalf of Fellows and Associates 12 volumes from the Science Library. During the same period 1298 signatures—including 33 on Saturday afternoons—were recorded in the Library Visitors' book by 279 individual visitors, including 23 on Saturday afternoons.

LINNEAN COLLECTIONS.—Further work for the preservation of the zoological collections has been carried out under the supervision of Dr. W. T. Calman. The Mollusca have received a preliminary cleaning, and have been placed in glass-topped boxes where possible. The Insecta have also been placed in glass-topped boxes, and the removal of the specimens—a delicate task—has been carried out satisfactorily by Mr. A. G. Gabriel, of the British Museum.

STAFF.—As is known to all Fellows, Lt.-Col. A. T. Gage resigned from the service of the Society in October last. During his period of office he had instituted many arrangements beneficial both to the Society and to the Staff. Following his retirement Mr. R. G. Pugsley was appointed to the Clerkship; and Miss M. Capes, as secretarial assistant, has proved of great service. Mr. W. S. Warton has performed the ordinary work of the Library with his usual competence. Frederick H. Jelly has carried out his duties as office boy in a manner which calls for special commendation.

At the conclusion of the Assistant-Secretary's report, the PRESIDENT appointed Mr. H. N. Ridley, C.M.G., Mr. S. Edwards, and Mr. J. T. Cunningham as Scrutineers of the Ballot.

The PRESIDENT then read the following account of the scientific work of Dr. KATHLEEN BEVER BLACKBURN, to whom the Trail Award and Medal had been assigned, and thereafter handed the Award and Medal to the recipient:—

I have great pleasure in presenting to you on behalf of the Linnean Society the (fifth) Trail Award, which was established by a donation from the late Professor J. W. H. Trail "to encourage study that throws light on the substance known as Protoplasm or the physical basis of life."

In making this award the Council have had under review the important contributions to cytology which you have made both independently and in collaboration with Professor Heslop Harrison.

Beginning your researches with a study of the seedling anatomy of Ranales, you soon turned your attention to the problems which continue to be the object of your researches. Here you may justly claim to have given the first definite proof of the existence of sex chromosomes in flowering plants, when in *Lychnis alba* you showed an XY pair of chromosomes in the male and a corresponding XX pair in the female.

More recently you have investigated chromosome numbers in *Silene* and neighbouring genera. In this laborious work more than eighty species were studied. A most interesting result here was the discovery of two races of *Silene ciliata*, one with 96 chromosomes, the other with 24, where the multiplication of chromosomes four times has made no obvious difference in its appearance.

In collaboration with Professor Heslop Harrison you have investigated the cytology of the genus *Rosa* and of the Salicaceæ. The importance of this research is increased by the comparative nature of your work, and for the light it throws on one aspect of the interpretation of species. Thus it appears that in British roses three of the five species given by Bentham are hybrids, and 98 per cent. of the microgenes are of hybrid origin, as shown by definite abnormality at microspore formation.

In handing you the Medal I wish you further successes in your interesting and important researches.

Dr. BLACKBURN having suitably acknowledged the presentation, the PRESIDENT then called upon Professor J. P. HILL, who had been selected as the recipient of the Linnean Gold Medal, and addressed him in the following words:—

The Council, on behalf of the Society, have this year selected Professor James Peter Hill, F.R.S., as the recipient of the Linnean Medal, the Society's highest award, as an expression of their estimate of the conspicuous value of his contributions to Mammalian Embryology.

Professor Hill was formerly Lecturer on Embryology in the University of Sydney, but he subsequently returned to England to take up the duties of the Jodrell Professorship of Zoology in

University College, London. He held this office from 1906 to 1921, when he became the first Professor of Embryology in the same College.

During his residence in Australia, the home of Marsupials, Professor Hill utilized to the full the opportunity afforded by his environment to study the embryology of this specially important group of Mammals. In 1897 he published a memoir on the development of the teeth in *Perameles* (Quart. J. Micr. Sci. xxxix, p. 427), written in collaboration with his colleague, Professor J. T. Wilson. This was followed by other important papers, on the same Marsupial, of which he was the sole author; mostly published in the 'Quarterly Journal of Microscopical Science' and the 'Proceedings of the Linnean Society of New South Wales.' Later work was principally concerned with the Monotremata and the Marsupialia, and the facts he has discovered with regard to their early development and their fœtal membranes are of special interest, in view of the primitive nature of these two groups. His discovery of an allantoic placenta in *Perameles* was specially noteworthy; and this led him to the conclusion that Marsupials and Placental Mammals were derived from a common ancestor in which a yolk-sac placenta was replaced during development by an allantoic placenta.

During recent years Professor Hill has given his attention mainly to the Primates. He has found that in the Lemuroids the chorion is vascularized precociously by the umbilical vessels, the allantois serving as a vesicular connecting stalk; and this brings these Mammals into line with other Primates. In 1929 he delivered the Croonian Lecture before the Royal Society, and in this he gave an important summary of the developmental history of the Primates.

Professor Hill's line of research involves patient and detailed investigation, which in his case has been coupled with great technical skill. His work has won for him a world-wide reputation as an authority on Mammalian Embryology.

Professor Hill expressed his profound appreciation of the honour that had been conferred upon him.

In the introductory passage to his Address the President made the following statements:—"As a matter worthy of special notice at this meeting, I have to call your attention to the fact that Mr. Monckton has just completed twenty-five years' service as Treasurer. We owe much to his capable management of our financial affairs, and in your name I desire to convey to him our grateful appreciation of the many services he has rendered to the Society.

"The retirement of Lt.-Col. A. T. Gage, C.I.E., our former Librarian and Assistant-Secretary, alluded to in my last Address as an impending event, has been duly accomplished. The duties of the office have been capably performed, since the beginning of

November, by Mr. S. Savage, to whom we wish a long and successful tenure of the post he now holds.

"During the Session just ending, the Society has passed certain alterations in its Bye-laws, one effect of which is to encourage the Fellows to assist the Council by nominating candidates as Foreign Members or as Associates. The simplification of procedure in elections thus introduced will prove, I think, to the advantage of the Society.

"Another instalment of the grant of £2000, made by the Carnegie United Kingdom Trustees for the benefit of the Library, has been received; and it is my pleasant duty once more to acknowledge the value of their gift, which has enabled the Society to purchase many expensive works which they would not otherwise have been able to obtain.

"The losses by death in our roll of Fellows have been unusually heavy. Although these will be dealt with more fully in the Obituary Notices, I think it is incumbent on me to mention several of the most noteworthy Fellows whose loss we deplore:—

"As in private duty bound, I must first refer to Sir Edwin Ray Lankester, for many years admittedly the leader of British Zoologists. Not only was he a naturalist of the first rank, but he was also a great teacher. There are many, like myself, who have to acknowledge a deep debt of gratitude to him for having first instructed them in the principles of their Science.

"Augustine Henry, whose genial personality endeared him to many friends, was a well-known botanist, who among other services had enriched the Western World with many notable plants made as the result of his extensive journeys in China.

"Harold Wager, another botanist of distinction, who had devoted himself to the study of the cytology of Fungi and of the general physiology of plants.

"Charles Edgar Salmon, a botanical member of the Council of the Society, and one of the best authorities on the British Flora.

"Charles Chilton, who did excellent work in the investigation of the Invertebrate fauna of New Zealand, with special reference to the Crustacea.

"Sir George Watt, late Reporter on Economic Products to the Government of India, and author of the standard 'Dictionary of Economic Products of India.'

"Martin Henry Foquet Sutton, an extensive traveller, who had done much for the improvement of Horticulture.

"James Cosmo Melvill, not only a competent botanist and the owner of a remarkably extensive herbarium, but a leading authority on Conchology, with a keen interest in Entomology and other branches of Natural History."

The PRESIDENT then delivered his Address on "Southern Whaling."

On its conclusion, Dr. A. B. Rendle, F.R.S., moved "That the President be thanked for his excellent Address, and that he be requested to allow it to be printed and circulated amongst the Fellows." The motion was seconded by Mr. R. H. Burne, F.R.S., and being put to the Meeting was carried with acclamation.

The Scrutineers of the Ballot, who had retired at the appointed times with the voting-lists for the election of the Council and of the Officers, having completed their scrutiny, reported to the President, and he declared the result as follows:—

Council for 1930–31.—Dr. G. P. Bidder; Mr. I. H. Burkill; Dr. E. J. Butler, C.I.E., F.R.S.; Major T. F. Chipp, M.C.; Dr. E. J. Collins; Mr. G. R. de Beer; Mr. Francis Druce; Dr. Philippa C. Esdaile; Professor R. R. Gates; Professor W. T. Gordon; Sir Sidney F. Harmer, K.B.E., F.R.S.; Professor H. S. Holden; Miss Gulielma Lister; Mr. G. W. E. Loder; Mr. H. W. Monckton; Mr. J. R. Norman; Mr. John Ramsbottom, O.B.E.; Dr. C. Tate Regan, F.R.S.; Lt.-Col. J. Stephenson, C.I.E., F.R.S.; Mr. A. J. Wilmott.

(The retiring Councillors were Mr. H. N. Dixon, Professor E. S. Goodrich, Dr. A. D. Imms, Dr. E. S. Russell, and Professor E. J. Salisbury.)

Officers for 1930–31.—*President*: Sir Sidney Frederic Harmer, K.B.E., F.R.S.; *Treasurer*: Mr. Horace W. Monckton; *Zoological Secretary*: Dr. George P. Bidder; *Botanical Secretary*: Mr. John Ramsbottom, O.B.E.

The President then announced that he appointed the following as the Vice-Presidents for 1930–31:—Mr. I. H. Burkill; Mr. G. W. E. Loder; Mr. Horace W. Monckton; Dr. C. Tate Regan.

Thereafter the President declared the Session of 1929–30 closed.

PRESIDENTIAL ADDRESS.

By Sir Sidney F. Harmer, K.B.E., Sc.D., F.R.S., P.L.S.

SOUTHERN WHALING.

(With 9 Graphs and 35 Tables.)

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In the Address which I delivered to this Society in 1928 I expressed my anxiety with regard to the effect of whaling operations on the stock of whales; and I alluded to the increased use of pelagic whaling, which seemed likely to result in a depletion of the stock within a short period of years. Much has happened since 1928; and, if anxiety was then justifiable, the events of the last two years may fairly be described as alarming.

In order to estimate the magnitude of the whaling operations then in progress, I had collected the figures relating to the season 1925/26, the result showing a production of 1,181,891 barrels of whale-oil, at about 6 barrels to the ton. I estimated the number of whales killed during that one year as not less than 30,000. The facts summarised in the following pages appear to me to justify the conclusion that the present position is one of extreme gravity.

I. Floating Factories and Pelagic Whaling.

The predominating facts which have influenced the growth of the whaling industry during the most recent years are the continued evolution of the type of ship known as a floating factory, and the increasing use which is being made of it in pelagic whaling. This form of hunting, which is carried on in the high seas, is no new method, since much of the whaling of the seventeenth to the nineteenth centuries was, in fact, pelagic. The ships used by the whalers of those days were small vessels of a few hundred tons; but large numbers of Greenland Whales, Southern Right Whales, and Sperm Whales were killed with their aid.

The history of the modern floating factory has been given by the editor of the 'Norsk Hvalfangst-Tidende,' Mr. Sigurd Risting *, who relates that on Aug. 10 he visited the monster floating factory 'Kosmos,' exactly twenty-five years after he had seen the steamship 'Admiralen,' which was the first floating factory to be used with success. C. Christensen had, however, made provisional attempts to utilize an oil-boiling installation on the small steamship 'Telegraf' in 1903. In 1904 'Admiralen,' of 1,500 tons, was fitted out for whaling off Svalbard (Spitsbergen), carrying an installation of open boilers; the carcasses being flensed at the side of the ship. Her oil-carrying capacity was 5,000 barrels.

The improved vessels which first went to the South Shetlands were of 3,000–4,000 tons, and could produce about 300 barrels of oil a day. In 1910/11 the size of the vessels at this locality was increased to 6,000 tons, with a daily production of 400 barrels; and the importance of "press-boilers" (closed boilers, in which a higher temperature than the boiling-point of water can be used) was becoming more and more realized.

After the Great War, continued efforts were made to increase the size of the boilers and to substitute tanks for barrels as oil-containers. The 'Ronald,' of the Hektor Company, was the most important floating factory, in both size and equipment, until the commencement of Ross Sea whaling. The shorter season available for hunting in that locality made further improvements necessary; and among these a

* N.H.T. 1929, No. 8, p. 202.

new type of boiler, the "Hartmann apparatus," was increasingly installed. The first expedition to enter the Ross Sea for whaling purposes, in 1923/24, consisted of the 'Sir James Clark Ross,' 12,000 tons, accompanied by five smaller vessels, the "whale-catchers," under the command of Capt. C. A. Larsen, who had been the first to hunt Rorquals and Humpbacks in Sub-Antarctic localities nearly twenty years earlier *.

The practice, adopted on some of the most modern factories, though not on all of them, of cutting up the whales on board, was introduced at this time, and has proved highly successful. This procedure had indeed been attempted at an earlier date, but the first really satisfactory arrangement had been constructed for Capt. Peter Sørlle on the 'Lancing.' There is now a whole fleet of floating factories whose size and productivity would not have been considered possible a few years ago. This evolution has, for the present, culminated in the building of the 'Kosmos,' of 22,000 tons. Open boilers have entirely disappeared and have been replaced by the Hartmann boilers.

One of the most noted of the modern floating factories is an oil-tank steamship of 15,000 tons, 527 feet long and 66½ feet broad, which was built in this country at Wallsend and was launched as the 'San Gregorio.' She was later renamed the 'C. A. Larsen,' and in 1926 was converted into a floating factory in Norway. She is provided with a bow-port about 18 feet in diameter, through which entire whales are hauled by powerful winches along a steel ramp, which rises to the flensing stage. The cutting up of the whales and the preparation of the oil and other products are operations which are carried out on board; and, like other vessels of this type, the floating factory is self-contained and does not require the assistance of a factory on shore.

The 'Kosmos' is an even larger ship, of over 22,000 tons, 550 feet long and 77 feet broad, the port for taking in whales being, as in most of the factories provided with this arrangement, at the stern end of the vessel. The whales are hauled, between the two funnels, to the flensing stage, which is extraordinarily large, extending the whole breadth of the ship and having an area of over 2,000 square metres. The real factory is below this deck, so that the whale-material can be dropped into the boilers through apertures in the stage. Large quantities of water are required for these operations, but an evaporator on board can prepare 250 tons of fresh water daily. The anticipated production of oil by the 'Kosmos' was 2,500 barrels a day, and her carrying capacity is 135,000 barrels. A normal production of 120,000 barrels was expected. The

* N.H.T. 1927, No. 11, p. 193.

operations of two days are accordingly capable of producing more oil than 'Admiralen' brought home as the result of a season's work during her first expedition. The actual catch of 119,434 barrels made by the 'Kosmos' in 1929/30 equals from $\frac{1}{6}$ to $\frac{1}{7}$ of the entire Antarctic production of 1925/26, the year which I specially considered in my 1928 Address: and the 'Kosmos' is one of many. Even if her average oil-production were 90 barrels a whale (a good figure), this amount of oil would represent 1,300–1,400 whales.

The institution of these powerful floating factories has revolutionized whaling. In 1925/26, as seen from my earlier figures (1928, p. 75), Antarctic localities contributed nearly 66 p. c. of the total production of 1,181,891 barrels. Of this, 34 p. c. belonged to South Georgia, 27·1 p. c. to the South Shetlands and the South Orkneys, and 4·8 p. c. to whaling of a purely pelagic type (Table 1). The whaling at South Georgia has been carried on mainly with the aid of land-factories; that at the South Shetlands principally by floating factories, which have made large use of the magnificent harbour at Deception Island and of other places where they could take shelter. Even if the S. Shetlands and the S. Orkneys are counted with the pelagic whaling, only 31·9 p. c. of the season's catch was obtained by Companies using floating factories.

The centre of gravity has shifted largely since 1925/26; but before considering this point further it is necessary to summarize the results of subsequent seasons (Table 1), which I have worked out from the returns published in various numbers of the Norwegian Whaling Gazette (N.H.T.). The figures for 1929/30 do not include the Non-Antarctic localities, the details of which have not at present been obtained. The total Antarctic production for this season is given as 2,532,445 barrels of oil; but the detailed returns are not yet available. The figures for the last two seasons, as compared with 1925/26 (Table 3), show that Norwegian whaling preponderates increasingly over that of the rest of the world, and is now more than two-thirds of the total.

The figures of the 1925/26 season were given in my earlier Address (1928, p. 76), and are summarised in Table 1, for comparison with 1928/29 (Table 2). The differences between the two seasons are indeed striking. The Antarctic oil-production has risen, in three years, from 65·9 to 86·6 p. c., and that from all other localities has fallen from 34·1 to 13·3 p. c. Examining the Antarctic figures, it will be seen that S. Georgia has fallen from 34·0 to 18·5 p. c. Ross Sea is nearly three times as high in the later season, the special characteristic of which, however, is the rise in the percentage for the S. Shetlands, S. Orkneys and W. Antarctic pelagic whaling from 28·5 to 58·3 p. c. Including the Ross Sea, the whaling

TABLE 1.—Barrels of oil produced, 1925/26–1929/30.

	1925/26.		1926/27.	1927/28.	1928/29.	1929/30.
Norsk Hvalf.-Tid.	1927, pp. 29 63.		1928, pp. 56, 58, 80.	1929, pp. 73, 84, 96, 102.	1930, pp. 54, 56, 78.	1930, pp. 165, 166.
South Georgia ...	401,147	34·0 p. c.	417,292	303,464	348,629	253,345
Ross Sea	39,630	3·4 „	110,070	186,400	185,592	347,370
South Shetlands...	294,340	24·8 „	272,684	400,367		
South Orkneys ...	27,050	2·3 „	42,000	44,700	1,097,119	1,931,730
W. Antarctic pelagic whaling.	17,000	1·4 „	30,270	92,700		
Antarctic localities (as above).	779,167	65·9 p. c.	872,316	1,027,631	1,631,340	2,532,445
Other localities ...	402,724	34·1 „	356,247	315,173	251,496	
Total.....	1,181,891	100·0 p. c.	1,228,563	1,342,804	1,882,836	2,532,445

in which is pelagic, with the W. Antarctic localities, pelagic whaling has risen from 31·9 p. c. in 1925/26 to 68·1 p. c. in 1928/29.

In Graph 1, representing the operations of the last five whaling seasons, I have grouped together the figures given under the headings of S. Shetlands, S. Orkneys, and W. Antarctic pelagic whaling in Table 1 ; the totals of these three components being 338,390 in 1925/26, 344,954 in 1926/27, and 537,767 in 1927/28. Owing to the changes which have

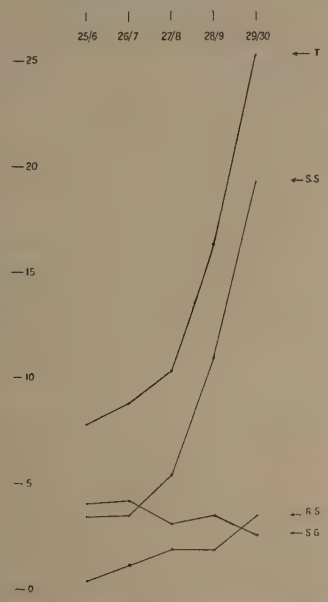
TABLE 2.—World-production, 1928/29 (N.H.T. 1930, pp. 54, 56, 78).

	Barrels of oil.		per cent.	Barrels.	per cent.
South Georgia		348,629	18·5		
Ross Sea		185,592	9·8	1,631,340	86·6
W. Antarctic .... (mainly pelagic).		1,097,119	58·3		
Africa, W. and S.		145,065	7·7		
N. Pacific—					
Western N. America ...	36,108				
Japan	7,248				
Mexico	8,346				
	51,702	51,702	2·7		
S. Pacific (Chili)		15,000	0·8	251,496	13·3
N. Atlantic—					
Arctic, etc.	11,375				
Norway	5,922				
Färoe and Shetland Is.	6,662				
Newfoundland and Labrador.	15,770				
	39,729	39,729	2·1		
		1,882,836	99·9	1,882,836	99·9

resulted from the extension of pelagic whaling during the last two seasons, it is no longer possible to treat the S. Shetlands or the S. Orkneys by themselves. The usual practice at present, even for the Companies holding licences at these two localities, is to send the factories first to the shifting ice-edge. The main area of these operations seems to have been hitherto in the neighbourhood of long. 20° W., sometimes to the

E. of S. Georgia and the S. Sandwich group, as far as Bouvet Id., sometimes to the W., past the S. Shetland Islands. The more sheltered whaling grounds of the S. Shetlands may be visited later, when the season is well advanced.

It will be seen from Graph 1 that S. Georgia has substantially fallen during the five seasons, and it appears to be on the down grade. The Ross Sea has risen to a greater extent. But the outstanding feature of the graph is due to the enormous increase in the activities of the pelagic whalers. This commenced after 1926/27, the rise in the next season being due to



Graph 1.—Antarctic localities. Oil-production, 1925/26 to 1929/30. Each unit in the scale represents 100,000 barrels, at 6 barrels to the ton. *R.S.*, Ross Sea; *S.G.*, S. Georgia; *S.S.*, S. Shetlands, S. Orkneys, and W. Antarctic pelagic whaling; *T.* total.

an increase of 127,683 barrels at the S. Shetlands, of 2,700 barrels at the S. Orkneys, and of 62,430 barrels in other pelagic whaling. A still greater rise occurred in 1928/29, and a further large increase in 1929/30.

The uppermost graph (*T*) represents the sum of the components of the three lower graphs; and its form is unmistakably due mainly to the increase in W. Antarctic pelagic

whaling (*S.S.*). Up to 1927/28, as shown in Table 4, the fleet of whaling vessels remained at the same level in that region, with 13 floating factories and 42 whale-catchers. In 1928/29 these numbers rose, respectively, to 22 and 73 ; and in 1929/30 to 32 and 139.

TABLE 3.—World-production, 1925/26, 1928/29, 1929/30 (Harmer, 1928, p. 74, and N.H.T., 1930, pp. 56, 78, 166).

	Barrels of oil.			Percentages.		
	1925/26.	1928/29.	1929/30*.	1925/26.	1928/29.	1929/30*.
Norwegian	655,608	1,210,235	1,720,775	55·5	64·3	68·0
Non-Norwegian	526,283	672,601	811,670	44·5	35·6	32·0
Total	1,181,891	1,882,836	2,532,445	100·0	99·9	100·0

* The figures for 1929/30 are those for the Antarctic area alone.

It is not merely an addition to the number of the whaling vessels, however, which accounts for the increased catch, but it is mainly a result of the fact that the floating factories of recent construction are immensely larger than their predecessors, as will be seen from p. 87, and can deal with a greater number of whales.

TABLE 4.—Pelagic whaling vessels, Antarctic *.

		1925/26.	1926/27.	1927/28.	1928/29.	1929/30.
Ross Sea.	Floating factories ...	1	3	3	3	5
	Whale-catchers ...	5	14	15	15	27
W. Antarctic pelagic whaling.	Floating factories ...	13	13	13	22	32
	Whale-catchers ...	42	42	42	73	139

* The figures for 1929/30 have been compiled from N.H.T. 1930, pp. 106, 112–115. Those for the earlier years are taken from the summaries of the operations of Norwegian and Non-Norwegian Companies which appear annually, generally in the 2nd–4th numbers of the journal.

Table 5 illustrates the changes which have occurred in the composition of the whaling fleet between 1925/26 and 1928/29, the season in which the expansion of pelagic whaling began to assume formidable proportions. The relative importance of land-factories and floating factories has altered. South Georgia remains the same, the manufacturing processes being

still conducted mainly at land-stations. A single land-factory remains at the S. Shetlands, but the rest of these factories are a proportion of the old shore-stations at Non-Antarctic localities, the total production of which forms but a small proportion of the world-catch. The Ross Sea fleet has been increased by the addition of two modern floating factories. In the W. Antarctic section, in which a sharp distinction can no longer be drawn between the S. Shetlands with the S. Orkneys and other pelagic whaling, the number of floating factories has risen from 13 to 22. Some of the older vessels remain in this section, but the new ships are of greatly increased power, as indicated by their production of 1,097,119 barrels of oil in 1928/29, as compared with 338,390 barrels in 1925/26.

TABLE 5.—Land-factories and whaling vessels, 1925/26 and 1928/29.

	1925/26.				1928/29.			
	Land-factories.	Floating factories.	Whale-catchers.	Total catch.	Land-factories.	Floating factories.	Whale-catchers.	Total catch.
uth Georgia ...	5	1	23	401,147	5	1	23	348,629
ss Sea	—	1	5	39,630	—	3	15	185,592
Shetlands	1	11	35	294,340	1	22	73	1,097,119
Orkneys	1	1	3	27,050				
. Antarctic pelagic whaling	—	1	4	17,000				
her localities ...	30	9	146	402,724	20	4	130	251,496
Total ...	37	24	216	1,181,891	26	30	241	1,882,836

As might have been anticipated, the larger floating factories involve a greater number of whale-catchers. The 'Kosmos' has 7 of these hunting boats, and several other ships have 5 or 6. The average proportion of whale-catchers to pelagic Antarctic factories has arisen from rather more than 3 to 1 to more than 4 to 1 in 1929/30 (see Table 4).

The total number of whales captured by Norwegian vessels in 1928/29 appears to have been 27,427, as ascertained from figures published by the Norwegian journal *. This compares with 26,962, the world-catch recorded by me for 1925/26 in my 1928 Address (p. 77). In view of the greatly increased production of oil in the later year I cannot help suspecting that the figure for that season has been underestimated.

* N.H.T. 1930, No. 3, p. 85. In the original table it is necessary to suppose that the fourth entry under Fin Whale should read 748 (as printed, 784), in order to make the additions correct.

The whales (Table 6, Norwegian Companies) tell the same story as the other figures. The Antarctic provided about three quarters of the total catch, and the rest of the world one quarter. The two pelagic areas together amounted to more than half the catch, and the W. Antarctic pelagic component to nearly one half. Africa is responsible for nearly half the whales captured in the rest of the world. Turning to the species caught, it will be observed that Blue Whales

TABLE 6.—Whales captured by Norwegian Companies in 1928/29 (N.H.T. 1930, p. 85).

	Blue Whale.	Fin Whale.	Hump-back.	Sei Whale.	Sperm Whale.	Not deter-mined.	Total.	Per cent.
South Georgia	1,560	3,130	15	396	31	—	5,132	18·7
Ross Sea	1,995	57	17	1	2	—	2,072	7·6
W. Antarctic pelagic whaling	9,179	3,502	16	411	29	—	13,137	47·9
Total, Antarctic	12,734	6,689	48	808	62	—	20,341	74·2
Africa	727	1,149	149	235	1,073	29	3,362	12·3
Pacific.....	115	1	16	—	—	1,109	1,241	4·5
Newfoundland	23	334	11	3	11	—	382	1·4
N. Sea.....	35	573	6	18	6	—	638	2·3
E. Asia	16	386	74	364	606	17	1,463	5·3
Total, Non-Antarctic ...	916	2,443	256	620	1,696	1,155	7,086	25·8
Total, Antarctic	12,734	6,689	48	808	62	—	20,341	74·2
Total for season.....	13,650	9,132	304	1,428	1,758	1,155	27,427	100·0

constituted nearly half the total number of whales of all species, and that the Antarctic catch of this species was nearly fourteen times as great as that of the rest of the world. Fin Whales are about 2·7 times as numerous in the Antarctic as elsewhere. The Sperm Whale is much more plentiful in the Non-Antarctic portion, but this might have been anticipated, since the species is typically an inhabitant of warm water.

The great predominance of Blue Whales and Fin Whales in the Antarctic returns is an obvious explanation of the fact that the oil-production of this area reached 86·6 p. c. of the total (see Table 2), while the number of Antarctic whales is only 74·2 p. c. of the total catch (Table 6, Norwegian Companies only).

I could hardly express myself too strongly with regard to the gravity of the position shown by the figures I have laid before you, particularly in view of the fact that a further expansion of the whaling industry is expected to occur in the coming season. The figures for 1929/30 are not quite complete, although, as they stand (Table 1), they are greatly in excess of those of 1928/29, with which I have dealt above. It does not need much foresight to believe that the culminating point of the industry must be reached within a very few years, if indeed it has not already arrived.

Anxiety is not confined, however, to those who regard the future of the great whales as a question of biological interest. The whaling community is becoming seriously concerned, and I subjoin evidence in support of this statement.

In one of the most recent numbers of the 'Norsk Hvalfangst-Tidende' (1930, p. 88), the editor discusses the results of 1928/29 in the Ross Sea, and compares this with earlier seasons. After calling attention to the very successful outcome of the season (during which the 'Kosmos' alone obtained no less than 119,434 barrels), he points out that there has been a continuous fall in the average length of the Blue Whales caught during three successive seasons. In 1926/27 the average length of all individuals (both sexes) was 85·20 feet; in 1927/28, 81·56 feet; and in 1928/29, 80·68 feet. His percentages of the frequencies of three length-classes for these seasons are shown in Table 7, with the percentages of sexually mature males and females, based on the conclusion of Messrs. Macintosh and Wheeler (1929, p. 417) that the minimum length at which southern Blue Whales become sexually mature is 77·75 feet in the female and 74·17 feet in the male.

Mr. Risting's comments are that there is a distinct decline in the average length of the Blue Whales caught in the Ross Sea, even though it is small; and that as a number of the females captured were pregnant the Blue Whales are being heavily taxed, "a taxation which meanwhile nothing can be done to prevent."

In the next number of the Norwegian journal (1930, p. 98) Mr. Risting prints an important article on whale-measurements, headed in heavy type:—

"The measurements show in the old fields of the Falkland Is. area a continued decline in the average length of the captured animals and a considerable fall in the percentage

number of sexually mature females, both for Blue Whales and for Fin Whales " (translation of original).

The estimate of Macintosh and Wheeler (*loc. cit.*) of 65·58 feet as the length at which the female Fin Whales reach sexual maturity is accepted as the basis of the calculations made for this species.

As in the case of the Ross Sea measurements, I have arranged Mr. Risting's figures in tabular form (Tables 8–10), and I first give some of his own comments.

(a) *Blue Whales, S. Georgia* (Table 8).—The decline in size is distinct. The steadily increasing percentage of the small individuals in Group I. is specially noteworthy.

TABLE 7.—Ross Sea, Blue Whale. Length-frequencies (both sexes) and percentages of sexually mature males and females (N.H.T. 1930, pp. 88, 90).

	1926/27.	1927/28.	1928/29.
I. 70 ft. and less	0·0	3·30	6·68
II. 71–85 ft.	53·83	76·50	72·83
III. 86 ft. and more	46·17	20·20	20·49
Total	100·0	100·0	100·0
Sexually mature males	98·7	92·5	91·6
„ „ females	88·0	87·0	86·6

(b) *Blue Whales, S. Shetlands* (Table 8).—The Western Antarctic whaling grounds include firstly the old hunting area of the S. Shetlands, where the catch is made principally in relatively sheltered waters, and secondly the area along the shifting ice-edge, in the eastern direction beyond the Falkland Is. Sector and as far south as Bouvet Id. The unlicensed Companies conduct their operations entirely along the ice-edge. The licensed Companies begin the season in these waters, but when the ice-catch has to be given up they retreat to their harbours in the S. Shetlands and continue whaling there until later in the season. (Mr. Risting has taken special care to keep his figures for these two constituents distinct.) As few Blue Whales were caught in 1926/27 from Deception Id., S. Shetlands, 1925/26 was chosen for comparison with the later years. " These statistics show that reckoned in percentages there are more and more immature individuals in the catch ; and, as we have previously

TABLE 8.—South Georgia, South Shetlands and ice-edge. Blue Whale, length-frequencies, both sexes (N.H.T. 1930, pp. 108–110).

	South Georgia.			South Shetlands, more sheltered waters.			Ice-edge, near S. Shetlands.	
	1926/27.	1927/28.	1928/29.	1925/26.	1927/28.	1928/29.	1925/26, 1927/28.	1928/29.
70 ft. and less ...	22·22	27·79	32·67	18·18	24·82	31·65		6·7
71–85 ft.	54·91	48·31	55·16	70·18	71·22	50·92	No figures.	77·8
86 ft. and more...	22·87	23·90	12·17	11·64	3·96	17·43		15·5
	100·0	100·0	100·0	100·0	100·0	100·0		100·0

TABLE 9.—South Georgia, South Shetlands and ice-edge. Fin Whale, length-frequencies, both sexes (N.H.T. 1930, pp. 117, 118, 122).

	South Georgia.			South Shetlands, more sheltered waters.			Ice-edge, near S. Shetlands.	
	1926/27.	1927/28.	1928/29.	1926/27.	1927/28.	1928/29.	1926/27, 1927/28.	1928/29.
55 ft. and less ...	7·07	5·65	7·91	5·08	15·36	7·23		3·54
56–65 ft.	20·85	30·58	39·51	52·56	48·96	58·46	No figures.	44·91
66 ft. and more..	72·08	63·77	52·58	42·36	35·68	34·31		51·55
	100·0	100·0	100·0	100·0	100·0	100·0		100·0

emphasized, this is a serious matter." In confirmation of this conclusion, a passage is quoted from the "Discovery" Report' (1929, p. 464) that "the killing of immature individuals is perhaps the worst form of interference with the natural replenishment of the stock." An earlier work by Risting (1928, pp. 34 *et seq.*), where this matter had previously been discussed, is also referred to.

TABLE 10.—South Georgia and South Shetlands and ice-edge. Blue Whale and Fin Whale. Sexually mature females, percentages of all females (N.H.T. 1930, pp. 108, 110, 117, 120, 122).

	Blue Whale.			
	1925/26.	1926/27.	1927/28.	1928/29.
South Georgia	—	68·91	57·91	46·92
South Shetlands, more sheltered waters	72·08	—	47·00	47·25
Ice-edge, near South Shetlands	—	—	—	78·16
Ross Sea	—	—	—	86·6

	Fin Whale.				
	1924/25.	1925/26.	1926/27.	1927/28.	1928/29.
South Georgia	—	—	80·76	72·56	61·37
South Shetlands, more sheltered waters	60·9	58·96	44·66	38·8	39·1
Ice-edge, near South Shetlands	—	—	—	—	65·56
Ross Sea	—	—	—	—	—

(c) *Blue Whales, sexually mature females* (Table 10).—With regard to this subject, Mr. Risting remarks that no definite falling off in the numbers of these individuals can at present be observed in the Blue Whales caught along the ice-edge, but the decline can be proved with full and indisputable certainty at the old whaling fields of South Georgia and the South Shetlands, and here it is considerable.

(d) *Fin Whales, sexually mature females* (Table 10).—At S. Georgia "the decline is nothing less than alarming." It

became evident in the Fin Whale sooner than in the Blue Whale, which is apparently failing to a greater extent. When both species are hunted in a locality the Blue Whale disappears sooner than the Fin Whale. This may be the result of the preferential killing of the larger Blue Whale, but it perhaps depends partly on Biological laws. The catch in the sheltered waters of the S. Shetlands, towards the close of the season, commonly consists mainly of Fin Whales.

At the S. Shetlands the decline is continuous from season to season.

I have so far merely indicated Risting's conclusions, to which I add a few remarks of my own.

In considering Tables 8 and 9, special attention may be given to Group III, which contains the largest individuals. It may be assumed that every effort is made to kill big whales, but the somewhat fluctuating figures of Group I (the smallest whales) might mean that the hunting of small individuals is deliberately avoided if larger specimens are available. In Group III of the Fin Whale (Table 9) the figures show a progressive decline, both at S. Georgia and at the S. Shetlands (sheltered waters). The small individuals (Group I) do not show a continuous alteration in this species, but in the Blue Whale (Table 8) there is a progressive rise in the percentage of young individuals from 1925/26 to 1928/29.

Table 10 gives evidence throughout that the stock of whales is deteriorating. Whichever locality is examined, whether for the Blue Whale or for the Fin Whale, there seems to be reason for supposing that the percentage of sexually mature females is falling. The percentage from the ice-edge, 1928/29, is higher than that of even the first of the seasons belonging to the S. Shetlands proper (Table 10). Even if the length-frequencies (Tables 8, 9) by themselves indicate mere fluctuations, of no real significance in this connexion, they are not unlikely, when taken in conjunction with the continuous fall in the percentages of sexually mature females (Table 10), to point to a tendency of grave significance.

Table 10 suggests the conclusion, which *a priori* is not improbable, that in a new Antarctic locality, previously not hunted, there is a high percentage of sexually mature individuals, and that, as time goes on, this percentage sinks if the killing is on too large a scale. In the Ross Sea, 1928/29, 86·6 p. c. of the female Blue Whales were sexually mature. At the ice-edge, another locality which has only recently been hunted on a large scale, the percentages were 78·16 for the Blue Whale and 65·56 for the Fin Whale, both numbers in striking contrast with the figures for the sheltered waters of the South Shetlands in the same season. The ice-edge figure for the

Blue Whale is noticeably lower than in the Ross Sea for the same season; but it is possible that the composition of the stock of whales along the ice-edge in the neighbourhood of the S. Shetlands had already been affected by the prolonged hunting at the S. Shetlands during earlier years. No figure is given for the Fin Whale in the Ross Sea; but the catch of this species is there almost negligible. The older whaling fields, S. Georgia and the S. Shetlands, seem to be far advanced in the deterioration of the stock.

Another conclusion which it seems legitimate to draw from these figures is that the whales do not wander at random throughout the Antarctic area, but are to some extent separated into assemblages which have preferences for particular localities. If this were not the case, it would be difficult to account for the fact that the percentage of sexually mature individuals appears to be correlated with the length of the period during which whales have been hunted in a locality. This has a possible bearing on a question which has often been raised—whether the inferiority in size of Northern Blue and Fin Whales, as compared with those of the Antarctic, indicates racial differences between two distinct stocks. The decline in the figures for the Southern whales may give an answer to this question. Is it possible that the smaller size of the Northern whales is due to the fact that these schools have been intensively hunted for many years? There are, in fact, a few old records of Northern Blue Whales stated to have exceeded 100 ft. in length; and a specimen believed to have been 98 ft. long entered the Panama Canal, lat. 9° 30′ N., in January 1922. The measurements of its axis vertebra, which was given to the British Museum, confirmed this estimate (Harmer, 1923, pp. 1085, 1088).

II. Whaling Statistics.

The great Antarctic whaling industry, which commenced some five years after the beginning of the present century, had not long been in existence before the Trustees of the British Museum began to consider the possibility that it would in due course result in a serious reduction of the number of whales. By an arrangement made with the Colonial Office, a system was inaugurated for receiving detailed statistics, which had been entered on special forms by the licensed whaling Companies and were submitted to the Natural History Branch of the Museum. These returns contain a record of the daily operations of the whaling vessels, each whale being individually mentioned, with a record of its species, sex and length; and, in the case of females observed to be pregnant, of the length of the fœtus. They have been carefully analysed and tabulated; the whales having been arranged, under

each species, in half-monthly periods. In most cases annual reports on the operations have been received from the Government of the Falkland Islands, to which and to the Colonial Office I wish to express my special thanks for the information on which this part of my Address is mainly based. Among the writers of these Reports I must specially mention Mr. A. G. Bennett, who has for many years devoted a large proportion of his time, at the Falkland Islands, to the study of whaling questions. He has throughout been in close contact with all the details of the industry, and has on various occasions made prolonged visits to the Antarctic whaling stations. His official Reports have contained many valuable suggestions. I have further to acknowledge his kindness in allowing me to read the manuscript of a general account of Antarctic whaling which he hopes to publish in the near future. Mr. Bennett's MSS. have been of great assistance to me in my studies ; and it is, in fact, difficult for me to disentangle the conclusions I have formed independently from those which may have been first suggested in these or other Reports. In any case, I desire to express my appreciation of the disinterested and patient work he has devoted to the problems connected with whaling. I have further to thank the Government of the Union of South Africa for the returns sent from Cape Colony and Natal, and the Trustees of the British Museum, who have kindly given me permission to make full use of all the whaling papers in their charge.

The Southern statistics of the British Museum (Natural History) consist of the following returns :—

South Shetlands, commencing		1917/18.
South Orkneys,	,,	1922/23.
South Georgia,	,,	1913/14.
Cape Colony,	,,	1918.) (No returns for
Natal,	,,	1918.) 1919 and 1921.)
Angola		1924 and 1925.

These papers contain detailed information with regard to many thousands of whales. They have been supplemented, for the purposes of this Address, by such information as I have been able to glean from other sources, principally from the numbers of the 'Norsk Hvalfangst-Tidende.' Figures for the whaling seasons generally can be obtained from this Journal ; but, as many of them refer solely to Norwegian Companies, they are often less comprehensive than my own, which include Companies that are not Norwegian. My figures are probably, in any case, a fully representative sample, and they have this advantage, that they can be analysed and tabulated in various ways. The summarized details of Antarctic Blue and Fin Whales are given in full in Tables 33–35 (pp. 158–160).

It has throughout been obvious that the distribution of whales has some relation to seasons and temperatures, and it appeared desirable to obtain information more precise in its character than the general remarks contained in the whaling reports. I accordingly applied to the Meteorological Office (Air Ministry), from which, through the kindness of the Director, Dr. G. C. Simpson, C.B., C.B.E., F.R.S., I have received a long series of records which have been of the greatest value to me in attempting to find correlations between temperatures and the incidence of whales. The papers which have proved most useful, in this connexion, are :—

South Orkneys (Laurie Island), 1913–1925. } Mean monthly
S. Georgia (Cumberland Bay), ,, –1929. } temperatures.

No records are available for the S. Shetlands, but the S. Orkneys are not far distant from that locality. The years to which the temperatures belong do not in all cases coincide with those of the whaling records so fully as would have been desirable. There are also records for :—

South Africa (Cape Town, 34° S.), 1913–1930.
,, ,, (Natal, Durban, 30° S.), 1913–1925.
West Africa (Loanda, 9° S.), 1915–1925.

I have not found time to study the African statistics and temperatures in sufficient detail to make much use of them.

In 1913 the late Major G. E. H. Barrett-Hamilton visited one of the whaling stations at S. Georgia, on behalf of the Government of the Falkland Islands, in order to make a preliminary examination of whales and the whaling industry generally. He commenced his work there on Nov. 15, 1913, but his labours were brought to an end by his untimely death, at S. Georgia, on Jan. 17, 1914. In these two short months he had accomplished a surprising amount of pioneer work, and he had laid foundations on which later investigations have been conducted. His notes were edited by Hinton, and were printed as a Report which is dated as "Received 1st April, 1915." It was long regarded as a confidential document, but the few remaining copies which had been printed ten years earlier were formally published in 1925 (see Hinton, M. A. C., 1925). This Report contains a mass of valuable information, a considerable part of which was contributed by Mr. Hinton. Major Barrett-Hamilton had clearly realised, however, the importance of most of the lines of investigation which have been adopted by his successors. He had paid special attention to the question of breeding, and had particularly noted the condition of the reproductive organs, including that of the *corpora lutea* of the ovaries, the importance of which has been further elucidated by Mackintosh and Wheeler (1929, pp. 387, 421). He had considered the question of the specific characters of

whales, their migrations, the period of ankylosis of the vertebral ephiphyses (as an indication of age) and the occurrence of parasites; and he had even observed the Diatom-film on the skin (mentioned by him on p. 137, as probably Algæ), later re-discovered by A. G. Bennett (1920).

In 1924 Wing-Commander H. M. Stanley Turner published a paper in which (p. 89) he indicated some of the most promising lines for future enquiry. He specially mentioned (p. 90) the importance of a study of the Graafian follicles of the ovary and the occurrence of *corpora lutea*, with a view to determining the breeding-season, and he states that this idea had occurred to him in 1913. From the evidence of correspondence I had with him in 1917 I have no doubt that he had realized the desirability of making investigations on these lines, quite independently of Major Barrett-Hamilton, who had had the same intention in mind before he left this country in 1913.

Some of the more notable works of later date, with a special bearing on my own studies, are given in the list on p. 161. Risting has published records and conclusions of great interest in his memoirs cited (1922, 1928) and in many scattered notices in the 'Norsk Hvalfangst-Tidende.' Kellogg (1929) has given a useful summary of the facts known with regard to migration. The accounts of Collett (1911–12) and Hjort and Ruud (1929) of the northern whales are indispensable for comparison with southern whales. Information respecting the pelagic floating factories at present in use can conveniently be obtained from Townsend's paper (1930). The 'Discovery' investigations now in progress are beginning to produce valuable results; and particular mention must be made of the important memoir by Macintosh and Wheeler (1929) on Blue and Fin Whales and the account by Hardy (1928) of the general work of the Expedition.

The assumption that whales undergo extensive annual migrations, in general terms from north to south and from south to north, is probably correct. The northward migration of the southern whales is believed to be undertaken for the purpose of breeding in warm water. The direct effects of variations of temperature are probably not important, in the case of the adults at least. The Sperm Whale, which is typically an inhabitant of warm water, is caught not infrequently off the S. Shetlands, at no great distance from the permanent Antarctic ice; and two individuals have been recorded from the Ross Sea in 1928–29 *. It is probably insulated by its blubber from an excess of heat as much as from an excess of cold. The Blue Whale, an ice-loving species, has (rarely) been recorded from near the Equator †.

* N.H.T. 1929, p. 325 (? inside the Ross Sea).
† *Ibid.* 1927, p. 15.

In newly-born Blue Whales and Fin Whales the blubber is extremely thin; and it is possible that these whales seek warmer water, not merely because of the necessity of bringing forth their young in relatively calm seas, but because the calves have no adequate protection against cold. It may be admitted that very little is known of the localities in which these species produce their young *, but the facts are better known in the case of the Humpback, which is said to breed in the neighbourhood of the Equator †. Dr. R. W. Gray ‡ has recently called attention to the fact that in the Greenland Whale, the Narwhal and the White Whale, all typically Arctic species which presumably breed in cold water, the epidermis of the newly-born individual is exceptionally thick; and this may well be a compensation for the absence, at this stage of its life, of an insulating coat of blubber §.

The southward migration (of the southern whales) is admittedly for the purpose of feeding. The warmer seas are deficient in the kind of plankton required for the nutrition of Whalebone Whales; a conclusion which is supported by the fact that at the beginning of the Antarctic season the Fin Whales (which probably come from the north) are in a poor and emaciated condition; while the oil-contents of the blubber increase largely in amount during their stay in Polar waters.

If any correlation can be found between the location of whales in a particular month and the local temperature of that month, it is probably not solely due to their preference for water of a particular temperature. It is obvious, however, that when the thermometer is below a certain point, the locality will be ice-bound, and that it is impossible for whales to be present in these conditions.

The active growth of the plankton on which the whales feed is probably directly correlated with temperature; although this is affected, not merely by increasing warmth of the air, as the season advances, but also by the effects of warm and cold ocean-currents. It might have been anticipated that when plankton was present in the greatest abundance, the whales would have been most numerous in the locality: and further that all species of Whalebone Whales would be similarly affected. Among the conclusions which have been reached by the 'Discovery' naturalists, no fact seems to me more surprising than that all the Whalebone Whales feed almost exclusively on the same organism, *Euphausia superba*, while they are in Antarctic waters (Mackintosh and Wheeler, 1929, p. 361). Without for a moment disputing the accuracy of the

* Harmer, 1928, p. 82. † Hinton, 1925, pp. 88, 180; Bull, 1929.
‡ 'Nature,' May 17, 1930, p. 744.
§ A suggestion made by me to Dr. Gray, *in litt.*, Apr. 20, 1930.

observations on which this statement is based, I have the greatest difficulty in believing that it is universally true of the Antarctic area generally ; even though Marshall (1930, p. 248) has ascertained, from an examination of stomach-contents, that, in every case satisfactorily examined, the Blue Whales in the Ross Sea were found to be feeding on *E. superba*.

This restricted use, by the two species, of a single article of diet does not occur in the Northern Hemisphere ; and the discussion of this subject by Hjort and Ruud (1929) may be studied with advantage. They quote G. O. Sars as their authority for the statement (pp. 69, 70) that the Blue Whale on the Norwegian coast feeds almost exclusively on the Euphausian *Thysanopoda* (or *Thysanoessa*) *inermis*, and that its appearance coincides with the spawning time of this Crustacean. The Fin Whale (*ibid.* p. 52) behaves differently, in the same locality, in the various months. Between the middle of January and the end of March its food consists of Herrings or *Thysanoessa*. On pp. 70, 102 they add that the Fin Whale also eats another fish, the Capelin (*Mallotus*) during the winter or spring. In April and the early part of May it feeds on either the Copepod *Calanus finmarchicus* or the " small krill " (*Thysanoessa inermis*), although there is little animal food present during this time. From the middle of May to the middle of August it lives exclusively on the " large krill " (*Meganyctiphanes norvegica*.) Does this possibly suggest an explanation of the perplexing behaviour of the Fin Whale, at least, in the Antarctic area ? It may be noted that Macintosh and Wheeler (1929, p. 361) mention two other species (not *E. superba*) of *Euphausia*, a *Nyctiphanes* and fish (this on only one occasion) as having been found in the stomachs of S. African Fin Whales. Their observations at S. Georgia were made from October to May, and those in S. Africa from June to October.

Hjort and Ruud's three periods correspond, respectively, with July to September, October to November, and November to February in the Antarctic. If the Fin Whale should be found to vary its food at different seasons in the south, it is possible that the early peaks, in October or November, of certain bimodal season-graphs at S. Georgia may have been caused by the occurrence of a different kind of plankton from that which is responsible for the later peaks. This would not entirely remove the difficulty, however, since the Blue and the Fin Whale maxima at this locality commonly occur either in the same month in a season or in two adjacent months, at S. Georgia.

Although the occurrence of *Euphausia superba* is clearly a dominating factor influencing the migration of Whalebone Whales to the Antarctic, the fact must be emphasized that the prevalence of this Crustacean at any time does not produce an

identical behaviour in the several species of whales. Each species has its own times and seasons; and this may be illustrated by the behaviour of the Sei Whale (Graph 2), the occurrence of which in a locality is specially restricted in time. During a period of 16 successive seasons (in 3 of which no Sei Whales were caught), 1,318 individuals of this species were killed at S. Georgia. 50·4 p. c. of this number were captured in March, 27·7 in April, and 15·0 in February—93·1 p. c. in these three months; leaving only 6·9 p. c. for the rest of the year. May produced 54 specimens in 1921/22, but only 12 in the rest of the seasons together.

Graph 2.—S. Georgia. Sei Whale. Monthly frequencies of 1,318 specimens captured during the period 1913/14 to 1928/29. S–A, September to August.

With the exception of 1927/28, in which 4 were captured in October and November, none have been recorded between June and the end of the calendar year. In January the catch, if any, has always been quite small; and the Sei Whale, at S. Georgia, is thus almost limited to the period February to April, of which March has contributed more than half the total catch for the 16 years. This is in striking contrast with the behaviour of the Blue and Fin Whales, the largest numbers of which are usually caught in December and January, months during which the Sei Whale is as a rule absent. It is believed by the whalers that the arrival of the Sei Whale is an indication that the best part of the season is over for the Blue and Fin Whales.

Whether the Blue and Fin Whales vary their diet or not in the south, it is impossible to consider their movements as single migrations. Evidence as to the direction from which they come may sometimes be obtained in more than one way. In the official Reports in the British Museum mention is repeatedly made of the fact that the condition of the Blue or Fin Whales, or of both kinds, has been either poor or good in certain months of stated seasons. In this connexion Mr. Bennett's interesting observation (1920) that the skin of the large whales is frequently covered by a film of innumerable Diatoms, and that this film is formed in Antarctic waters, is important. If the film is present it indicates that the whale has been feeding in the far south ; and its condition is often found to be good. If it is absent, and if the whale is thin, its blubber being deficient in oil, it has probably come from the north, where food is scarce. A further line of evidence is afforded by the curious large open pits, described by Mackintosh and Wheeler (1929, p. 374), on the skin of nearly all the Blue and Fin Whales at Saldanha Bay, S. Africa. The nature of these wounds has not at present been ascertained ; but the injuries are recognizable at S. Georgia, where the partially healed pits, or scars representing them, are found on all Blue and Fin Whales caught. The occurrence of these marks at the Antarctic localities thus indicates that the whales in question have spent some time in more northern waters. The external parasite *Pennella*, a remarkable Copepod Crustacean, gives similar evidence, since there is reason to believe that whales become infected with it in the warmer waters and lose it in the colder seas of the south (*ibid.* p. 373).

It appears to be a well ascertained fact that, at all the Antarctic localities, large and fat Blue Whales normally appear at the beginning of the season, and soon depart. At the S. Shetlands, to which most of these statements (in official reports) refer, they seem to leave about the beginning of January, when large numbers of young Blue Whales appear. These, the "Myrbjørner" of the whalers, are frequently referred to as being in poor condition ; and it can hardly be doubted that they have come from the north, where they were born. Emaciated Fin Whales also appear after the New Year at S. Georgia ; and whales of this species seem to remain poor, as a general rule, till about February, or, not infrequently, throughout the season. In an official Report, by Mr. A. G. Bennett, on the S. Shetlands season 1925/26, it is stated that the Fin Whales were in poor condition, and exceptionally thin, "which seems to be the regular thing in big Fin Whale years." I have tested this statement, by reference to reports on other seasons, both at S. Georgia and at the S. Shetlands, and I have found a considerable amount of evidence which supports

it. In his Report on the S. Shetlands season 1926/27 Mr. Bennett remarks that the Fin Whales caught in November, very early for this species, were more or less covered with Diatoms. In a Report on the S. Orkneys season 1922/23 it is stated that from Jan. 10 to Jan. 18 there was a great influx of Fin Whales, but the blubber was thin and dry. It was added that they had probably come from warmer waters, as the parasitic marks on the skin were fresh and raw. The Fin Whales are reported as improving in March, in more than one Report; and this is presumably due to their sojourn in Antarctic waters. Large whales may re-appear at the end of the season, as in the case of the Blue Whale at the S. Shetlands 1925/26 (see p. 115).

The various maxima noticed in the season-graphs are thus not necessarily due to the continued migration of a single stock of whales. There is good reason for believing that they are, or may be, the resultant of a complex series of movements, partly of whales, often immature, from the north, and partly of well-fed individuals moving northwards from their Antarctic feeding-grounds.

It must not be assumed, however, that a northward movement is restricted to the end of the season, when many of the whales are presumably leaving the southern localities altogether. In his Report on the S. Shetlands 1926/27 Mr. Bennett states that the early Blue Whales of this species caught in the ice to the E. of the islands were all travelling E. or N.E. In the S. Orkneys Report for 1922/23, the fact is noted that hundreds of Blue Whales were met with during the journey from S. Georgia, until the vessel was about 80 miles from land, and that they were all travelling N.E. towards S. Georgia. Practically no catch of this species was made in the season until the second half of December. Further evidence on migration is given in Mr. Riches' S. Shetlands Report for 1923/24, a season which extended from November to April. Enormous numbers of whales were seen by arriving boats, 200 miles to the N.E. of the islands; and large numbers were noticed 150–200 miles N. of Livingstone Id. on the final departure. From the Report on the S. Orkneys season 1925/26 it appears that during the voyage from S. Georgia schools of Fin Whales were met; but the Blue Whales were not seen until the pack-ice was reached.

Some information with regard to migration can clearly be ascertained from a consideration of the periods of the year during which whales are to be found on the several hunting-grounds. In each locality whales are captured in certain months, in one or more of which specially large numbers are killed. The size of the monthly catch must have some relation to the actual frequency of the whales; and the statistics have accordingly been dealt with by reducing the monthly numbers

to percentages of the total catch of the species for the season, and representing them as "season-graphs." These are by no means identical in form, in different seasons, for the same species of whale at the same locality; but the variations have their limitations. It is possible to draw from them certain broad conclusions, such as, for instance, that the Blue Whale and the Fin Whale commonly reach their maximum at or near Midsummer (December and January) in the Antarctic localities; and in the winter (June to October) off S. Africa. These are, however, matters of common knowledge.

Certain obvious considerations suggest that the graphs do not always represent the actual frequency of whales during the months of the season. A high frequency clearly implies that many were present, but the converse conclusion is not necessarily valid. The statistics may have been carelessly drawn up, and there is unfortunately reason to suppose that in a few instances entries have been deliberately falsified. In the main I think that the statistics may be regarded as reliable, or at least as fairly representing the facts. But even if they have been prepared with the most scrupulous regard for accuracy, they may be misleading, for some of the following reasons. In the Antarctic area the weather is abnormally stormy, and there may be days or weeks during which whales cannot be caught, although they are actually abundant at the time. Labour troubles or a shortage of coal have often interfered with the whaling, and a vessel may spend unprofitable days in moving from place to place in the search for whales. The length of the season has not been identical in all years; and there are instances in which operations have not commenced until one or more of the best months have passed. These months are not represented in the season-graph, and their absence throws the succeeding months into undue prominence. When Fin Whales are present with Blue Whales (as is usually the case) the Blue Whale is the preferred object of the chase, as being the more productive animal. In seasons or months in which Blue Whales are abundant the number of Fin Whales killed may be relatively small, not because they are scarce, but because their capture has been deliberately avoided. It should further be borne in mind that during the Antarctic summer the whaling day may be 24 hours long; but, later in the season, with rapidly shortening daylight, its length is greatly reduced. A high percentage of the total catch in any month from March to May is, for this reason, more noteworthy than a high level in December or January. For these or other causes, a month during which whales are in fact numerous may be represented by a low level in the graph.

It is found, on the other hand, that, in comparing the results of successive seasons, the graph which represents any species

may have typical characters, which are not identical in different localities. If the same type of graph recurs commonly in the same whaling field, there is some reason to suppose that its form is not entirely due to accidents of no real significance.

The season-graph frequently has a single high and sharp peak (of the form shown in Graph 2, p. 106), implying that the catch has reached a well-marked maximum in a particular month ; the two months on either side of it having a much lower catch. Unimodal graphs of this type are often symmetrical. In other instances two or three consecutive months of the most productive period may have nearly equal catches, and the graphs are accordingly obtuse and low. Other graphs are bimodal, with two peaks (Graph 3, *a*, p. 114) ; and others are more irregular. Although the numbers of seasons on which the following results are based are not large, the evidence seems to justify the conclusion that the graphs typically have characters as follows ; although all seasons are not found to agree with this classification.

Unimodal graphs.

Blue Whale.—Ross Sea ; W. Antarctic pelagic whaling ; S. Shetlands ; S. Orkneys ; S. Georgia ; Natal.
Fin Whale.—S. Shetlands ; S. Orkneys ; Natal.
Sei Whale.—S. Georgia.
Humpback.—S. Shetlands ; French Congo.

Bimodal graphs.

Blue Whale.—Cape Colony.
Fin Whale.—S. Georgia (unimodal in certain seasons) ; Cape Colony.
Sei Whale.—Cape Colony ; Natal.
Humpback.—S. Georgia ; Natal ; Angola (W. Africa).
Sperm Whale.—Cape Colony ; Natal.

It appears probable that the bimodal season-graphs do not necessarily represent the same facts, and that the following possibilities at least have to be considered in interpreting them :—(1) a depression between two peaks may be due merely to bad weather which has interrupted the catch ; (2) the bimodal form may indicate that the main migration has passed the locality on two occasions ; (3) it may be produced by two successive waves of migration, perhaps of adult individuals arriving from one direction and of immature whales coming from another.

The examination of the graphs * shows that, in the same locality, the figures may be very much alike for one of the

* For the Antarctic localities the graphs can easily be reconstructed after reducing the numbers given in Tables 33–35 (pp. 158–160) to percentages of the total catch.

species, either the Blue Whale or the Fin Whale, in two or more seasons. It is generally found that the graphs for the other species, in the same seasons, are by no means alike, and may be widely different. In spite of the fact that the Blue Whale and the Fin Whale are believed to feed on the same organism (in Antarctic waters), it cannot be said that a prevalence of this food usually produces a similar concentration of the two species of whales.

On attempting to group similar graphs together, it is often found that the best correlation, for either species by itself, is obtained by grouping the graphs from different localities. It seems probable that there are certain conditions of weather and temperature which lead, indirectly, to a concentration of one or the other of the species of Rorquals ; and that these conditions are different for the Blue Whale and the Fin Whale. The right conditions, for either species, occur sometimes at S. Georgia, sometimes at the S. Shetlands, and sometimes at the S. Orkneys. If this assumption is correct, the resemblance of graphs representing different localities may have some significance. But it must be emphasized that if a succesful grouping of the graphs of different seasons and different localities has been made for the Blue Whale, the corresponding graphs for the Fin Whale, if assembled, will probably be found to have no special resemblance to one another ; and *vice versa*. The two species are differently affected by the same conditions ; and the Antarctic area is a feeding-ground which they probably reach by different routes.

A unimodal season-graph may imply the occurrence of only one period during which the conditions leading to the concentration of a species of whale are as favourable as they can be. A graph of this kind is likely to be found on plotting the records of a station which is terminal in respect of the main migratory movements, whether at the northern or at the southern end of the route. In a locality which is passed by the schools migrating northwards, and again by the same schools on their return journey to the south, there is naturally an intermediate period when whales are absent or few ; and this should result in a bimodal season-graph.

The classification of the graphs given on p. 110 definitely supports this view. The Blue Whale is typically unimodal in the far south ; and it is certain that it cannot go south of the Ross Sea. It is generally unimodal at S. Georgia, where bimodal graphs may occur. The second mode, in this case, may sometimes indicate a return to the island of whales which have gone further south after their first visit. The two modes may also imply distinct visitations by schools of adult individuals which have come from one direction and parties of young whales which have arrived from another.

Examining the returns for the Blue Whale at more northern stations :—in the graphs for Cape Colony (34° S.), an intermediate locality, 1924 is unimodal and symmetrical, but in the others there are irregularities which may indicate more than one visitation. At Walvis Bay (22°–23° S.), some 12 degrees further up the W. African coast, four seasons (1924–1927) are markedly unimodal, all with the peak in August ; and off Mossamedes, Angola (15° S.), in the same four seasons, the graphs are also typically unimodal, the peak (July or August) being on the whole sharper and more accentuated than in the graphs representing Walvis Bay. The sharper graphs seem to indicate that Angola is nearer the northern extremity of the Blue Whale's migration than is Walvis Bay ; and this is confirmed by the fact that this species is barely represented near the Equator by one or two individuals recorded from the French Congo.

The suggestion that a bimodal graph commonly indicates a locality which is passed twice is supported by the list, on p. 110, of the localities in which the whaling results are usually represented by such graphs. Cape Colony is typically bimodal for the Blue Whale, the Fin Whale (Table 19, p. 135), the Sei Whale and the Sperm Whale ; and it cannot be regarded as a terminal point of the migration of any species of whale. The number of Humpbacks caught in this locality is too small to allow any generalization to be made ; but I infer that the large migrations of this species which are certainly known to occur off W. Africa touch the coast at some point N. of Cape Town. In the case of the Fin Whale there is generally an early peak in May to July and a late peak in October or November.

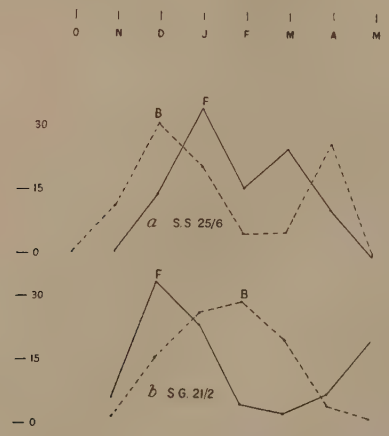
Natal (Durban, 30° S.) is not on this line of migration, and its whaling returns are very different from those of localities on the W. coast ; as the result of the influence of the warm water of the Indian Ocean. The Blue Whale and the Fin Whale have unimodal graphs in this locality ; in both species usually with the mode in June or July (Table 19). This may be taken to mean that they do not travel much beyond Durban along the E. coast of Africa. The Sperm Whale and the Humpback are, however, bimodal at Durban ; and it is well known that these species migrate from the Antarctic ice to the neighbourhood of the Equator ; or probably beyond it, in the case of the Sperm Whale. At Durban the modes of the Humpback are usually in July and September ; and at the French Congo, practically on the Equator, the single mode was in July/August in 4 out of 5 seasons. Angola was bimodal (July, October) for the Humpback, in 1924 and 1925, another fact which agrees with the hypothesis suggested. S. Georgia has on several occasions shown a secondary peak late in the

season, in addition to the much higher principal peak occurring from November to January ; and it may thus be considered bimodal for the Humpback. The S. Shetlands are unimodal for this species ; but, owing to restrictions in its catch, recent years do not give a satisfactory record of its occurrence in the Antarctic. S. Georgia is frequently, but not always, bimodal for the Fin Whale, of which there appear to be two visitations in certain seasons.

The general nature of the migrations of southern whales has been discussed by Messrs. Macintosh and Wheeler in the ' Discovery ' Reports (1929, pp. 453–467), with special reference to the observations made by them at the whaling station of the Compañia Argentina de Pesca at S. Georgia. Their results are accordingly based on but a portion of the entire catch at this locality. The season 1925/26 was markedly a Fin Whale year (see Table 32, p. 152). In the portion of the catch investigated, whales were very scarce in October, November, and December. The few individuals taken at the beginning of the season were mostly large, but they became more and more scarce, and the Blue Whales almost disappeared. The weather during this period was on the whole fine, food seemed to be plentiful, and a rather high proportion of the whales were pregnant. At the end of December an immense number of Fin Whales appeared, and during January the males were about twice as numerous as the females. The average length of both sexes declined during February and March, when the proportion of females rose—evidently the result of an influx of immature whales, the percentage of which increased from about 10 in January to about 50 in March. Pregnant females declined, during the same months, from 61 to 17 p. c. Few Blue Whales were caught during this period, but there was a slight influx of small ones which became quite marked at the beginning of March. Taking the season as a whole, the majority of the Fin Whales were adult and most of the Blue Whales were immature. From the consideration of these and other facts the two authors come to the conclusion (p. 462) that the whale-population is composed partly of the main stock, the movements of which are probably controlled largely by the distribution of food and by meteorological conditions, and partly of whales which appear at S. Georgia independently of the main stock. Among these are the lactating females and a more important constituent, the immature whales. The opinion is expressed that during the greater part of the season the tendency is for whales either to leave S. Georgia to go further south or to arrive there from the direction of the Equator.

My own evidence, some of which is given in detail below, is entirely in favour of the opinion of Macintosh and Wheeler

that the composition of the schools of whales visiting a locality varies from time to time. At one moment the stock may consist principally of adult individuals, and at another of young ones. If food-conditions are favourable the whales probably linger in the locality, but in other circumstances they may be merely passing it on their way to some other place. It is not unlikely that the young and many of the old whales arrive from different starting-points, widely distant from one another. We are dealing, in fact, not with a single, long-continued movement in one direction, but with a series of wave-like incursions, which may continue throughout the season.

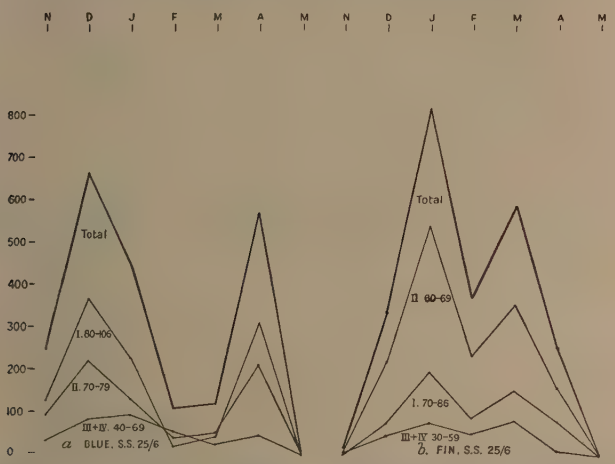


Graph 3.—Season-graphs, *a*, *S.S.*, S. Shetlands, 1925/26; *b*, *S.G.*, S. Georgia, 1921/22. *B*, Blue Whale (broken lines); *F*, Fin Whale; O–M, October to May; percentages, in total catch of the species, in the margin.

It would be desirable to make a complete analysis of all the whaling returns, in order to ascertain the exact composition of the stock in every month. This would be a very laborious undertaking; and I have not been able to work out the necessary figures for more than a part of two seasons. The differences between them will serve to illustrate the complex nature of the factors which produce a given type of season-graph. I have selected 1925/26 (S. Shetlands) and 1921/22 (S. Georgia), the choice being determined by the fact that each of these has certain special features (see Graph 3). 1925/26 was unique at the S. Shetlands in having bimodal season-graphs in both species, the peaks of the Blue Whale occurring in December and April, and those of the Fin Whale

in January and March. My results for the S. Shetlands may be compared with those of Macintosh and Wheeler, during the same season, for S. Georgia. In 1921/22 (S. Georgia) the Blue Whale season-graph is high and unimodal (Jan./Feb.), while that of the Fin Whale is bimodal, with pronounced peaks in December and May—the latter a very unusual feature.

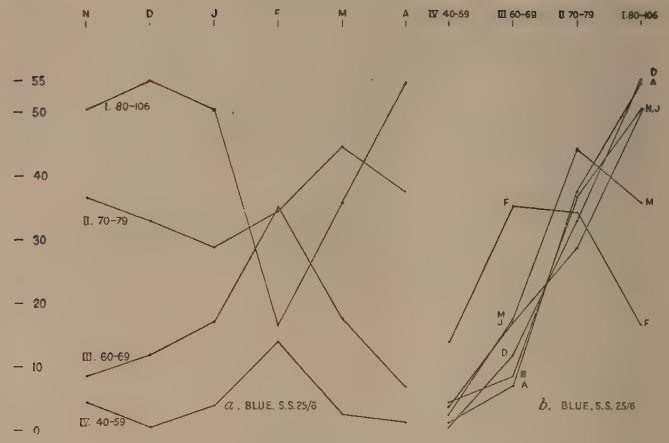
S. Shetlands, 1925/26. *Blue Whale.* Total catch, 2,166 (Tables 11, 12, pp. 117, 118).



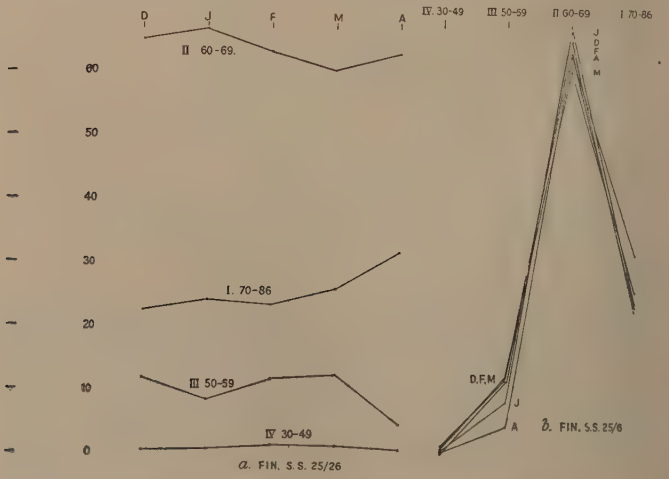
Graph 4.—S. Shetlands, 1925/26. *a*, Blue Whale and *b*, Fin Whale. Total catch and monthly catches of three length-classes, in feet, as indicated. The figures are the actual numbers caught. N–M, November to May.

The graph (Graph 4, *a*) representing the total (actual) numbers of whales naturally corresponds in form with the season-graph (Graph 3, *a*). The April mode is the sum of the peaks of all the classes, and it is evident that the larger whales (classes I and II) were mainly responsible for its prominence. Small whales (class III+IV) were relatively few and were slightly more numerous in January than in December, the month in which the season-graph and those of classes I and II reach their maximum.

The percentages of the total catch in each month have been arranged in two groups of graphs :—Graph 5, *a*, to show the frequencies of each length-class in the months ; and Graph 5, *b*, to show the same frequencies for each month separately.



GRAPH 5.—S. Shetlands, 1925/26. Blue Whale. *a*, frequencies of four length-classes, in feet, as indicated, November to April (N–A); *b*, the same frequencies, in each month separately. Percentages, in total catch of the species in each month, in the margin.



GRAPH 6.—S. Shetlands, 1925/26. Fin Whale. *a*, frequencies of four length-classes, in feet, as indicated, December to April (D–A); *b*, the same frequencies, in each month separately. Percentages, in total catch of the species in each month, in the margin.

These graphs are widely different from those shown in Graph 4, *a*, because they take no account of the actual numbers of whales (Table 11). Graph 5, *a* might suggest that the individuals of 70–79 ft. were most frequent in March, but it is merely the percentage of that month that is highest. The percentage of 44·1 in March represents 53 out of a total of 120 whales; but the lower percentage of 37·5 in April represents 213 out of 568. The graph thus shows merely the composition of the catch in each month; and the percentages of February, with only 108 whales, are on the same scale as those of December, with more than six times the number (663).

TABLE 11.—Blue Whale and Fin Whale. S. Shetlands, 1925/26 and S. Georgia, 1921/22. Actual numbers caught.

	S. Shetlands, 1925/26.		S. Georgia, 1921/22.	
Length in feet.	Blue Whale.	Fin Whale.	Blue Whale.	Fin Whale.
30–39	—	1 } IV		1 } IV
40–49	4 } IV	24 }	} 49 IV	30 }
50–59	52 }	239 III	}	109 III
60–69	273 III	1,524 II	206 III	219 II
70–79	744 II	576 } I	589 II	} 152 I
80–89	985 } I	18 }	779 } I	}
90–106	108 }		199 }	
Total	2,166	2,382	1,822	511

Graph 5, *a* is instructive, however, in showing that the composition of the catch varied considerably from month to month. The graphs of classes III and IV (smaller whales) are seen to be inverse to that of class I (80–106 ft.). As they represent only 15·3 p. c. of the total catch, they have an insignificant effect in shaping the season-graph, as compared with class I, which includes 50·4 p. c. of the season's catch, or with class II (70–79 ft.), with 34·4 p. c. It is to be noted that the graph of II differs considerably in form from the others. Large whales were relatively numerous at the beginning and end of the season. It is curious that the percentage in class I is identical (50·4) in November and January; and is almost the same, 54·9 and 54·4 respectively, in December and April. This class sank to a low figure (16·6 p. c.) in February, and

thence rose by two equal increments to the April maximum. Class II was relatively high in November (36·6), sank to 28·7 in January, then rising to 44·1 in March and falling to 37·5 in April. The smallest whales became relatively more numerous as the largest ones declined ; and *vice versa*.

TABLE 12.—Blue Whale and Fin Whale. S. Shetlands, 1925/26 and S. Georgia, 1921/22. Half-monthly catches (actual).

	S. Shetlands, 1925/26.		S. Georgia, 1921/22.	
	Blue Whale.	Fin Whale	Blue Whale.	Fin Whale.
Oct 2. ...	6	—	—	—
Nov. 1 ...	40	—	—	—
„ 2 ...	208	19	32	33
Dec. 1 ...	342	132	150	62
„ 2 ...	321	204	136	110
Jan. 1 ...	310	485	228	81
„ 2 ..	136	330	256	41
Feb. 1 ...	80	280	272	8
„ 2 ...	28	91	256	18
Mar. 1 ...	42	308	219	9
„ 2 ...	78	278	150	7
Apr. 1 ...	261	132	71	13
„ 2 ...	307	120	21	26
May 1 ...	7	3	16	38
„ 2 ...	—	—	15	65
Total ...	2,166	2,382	1,822	511

In Graph 5, *b* each graph is constituted by the frequencies shown in one of the vertical lines of 5, *a* ; but it is obvious that these occur in a different sequence. These graphs demonstrate the fact that there was little difference between the constitution of the catch in November, December, January, and April, in all of which the frequencies increase from class IV to I. March differs from these months in the fact that class II

surpasses I; while in February the difference is greater, since class III slightly surpasses II and is considerably higher than I.

S. Shetlands, 1925/26. *Fin Whale*. Total catch, 2,382 (Tables 11, 12, pp. 117, 118).

Graph 4, *b* (p. 115) shows the actual numbers, total and length-classes, for each month of the season. The peaks and depressions of the classes correspond even more closely with those of the total catch than is the case in the Blue Whale (Graph 4, *a*). A striking difference between the species is at once apparent. Class II, the whales of intermediate size, is predominant; and I, which in the Blue Whale was in that position, is distinctly inferior to it. Graph 6, *a* (p. 116), which should be compared with 5, *a* (Blue Whale), shows that class II was predominant, not only in actual numbers, but also in the percentage composition of every month. The numbers range from 60·2 to 66·5, those of class I being on the much lower level of 22·6 to 31·7. Graph 6, *b* is even more striking, and it demonstrates the fact that the composition of the Fin Whale catch remained practically unaltered throughout the season, instead of showing a marked difference between February and March and the other months, as was the case in the Blue Whale (5, *b*). It is obvious that there was a profound difference in the behaviour of the two species.

The British Museum fortunately has an excellent report on this season, by Mr. A. G. Bennett, who left the Falkland Is. on Oct. 30, on his way to the S. Shetlands. Pack-ice was encountered in 57° 10′ S., very solid and heavy. Many whales were seen at first, but they no longer appeared when the ship penetrated further into the ice. Bransfield Straits were solidly packed, and Admiralty Bay was ice-bound on Nov. 10. No whales were found, and the season was very cold, with 6° F. of frost. Blue Whales were discovered, however, N.E. of Clarence Id., a part of the Weddell Sea where there was some open water, some 200 miles from Admiralty Bay. No work was at first possible at Deception Id. Good catches were made in December, when the ice gradually cleared away. January was a good month for whales, but the weather was bad. The catches became deplorable after Jan. 25; and February was even worse, with storm, fog, and low temperature. In March there was some improvement, but the temperature was seldom above 32° F., and was often down to 12° F., so that the spray froze on the ships. April had the best weather, and a number of really good Blue Whales were obtained. In spite of these disadvantages, the season's results were particularly good. The Fin Whales were exceptionally thin, as usually happens in big Fin Whale years.

Mr. Bennett's account agrees well with the Meteorological Office figures for the S. Orkneys, and helps to explain them. These end with December 1925; but they just include the months of most importance in connexion with the season 1925/26. The winter had been moderately cold, with mean temperatures as follows:—June, 12·9; July, 14·9; Aug., 15·8; Sept., 12·9; Oct., 20·0; Nov., 27·4. All these figures are below the freezing-point of sea water; but in December the thermometer rose to 31·6, which is above that temperature and is 1° above the statistical mean for the month. It will be noticed, from Mr. Bennett's account, that it was in December that the ice gradually cleared away.

The general similarity of the bimodal season-graphs (Graph 3, *a*, p. 114) is emphatically not the result of a resemblance between the two species in the composition of the stock during the several months. The weather-conditions are no doubt partly responsible for their form, but not entirely. Omitting the beginning and the end of the season, it will be seen from Table 12 (p. 118) that the catch was conspicuously low during the whole of February and March for the Blue Whale, and only in the second half of February for the Fin Whale. During this half month, it may be assumed that the small catch of both species was probably due to bad weather; but in the other half of February and in the whole of March the number of Fin Whales was not specially low. Mr. Bennett states that the catch became deplorable after Jan. 25; and if it be assumed that during the last week of this month and the whole of February the number of Fin Whales killed was, owing to this cause, less than it might have been, it seems probable that their season-graph is misleading. With good weather throughout, this might have been unimodal, with its summit in January or February. The fact that the composition of the stock was extraordinarily uniform throughout the season in the Fin Whale renders this suggestion plausible. As indicating that the form of the graphs is not entirely due to the weather, it is important to notice that a low Blue Whale figure coincided with a relatively good Fin Whale catch in the first half of February and in the whole of March (Table 12), and that this result was reversed in the first half of December and in the whole of April, when good catches of Blue Whales were made, as stated by Mr. Bennett.

In the case of the Blue Whale, I think that the bimodal season-graph probably points to the conclusion that the whales were really abundant in December and April, and scarce in February and March, even if their numbers caught during the last-mentioned months were adversely affected by the weather. It has been shown above that the prominence of the two peaks is principally the result of the capture of considerable numbers of the largest whales in November, December,

January, and April. An additional reason for supposing that the February and March totals are significant is the close resemblance between the graphs for classes III and IV (Graph 5, *a*, p. 116), the percentages of which were correlated, in spite of the low totals from which they were calculated.

S. Georgia, 1921/22. *Blue Whale.* Total catch, 1,822 (Tables 11, 12, pp. 117, 118).

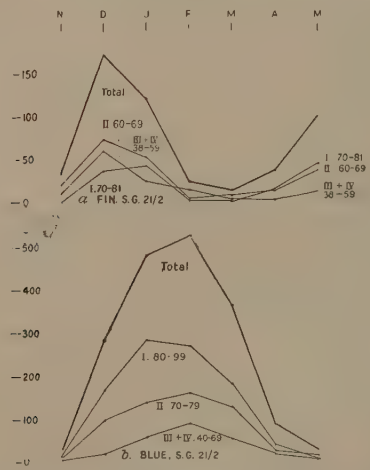
The season-graph (Graph 7, *b*) is unimodal, with January and February nearly equal. The half-monthly figures (Table 12), except in the second half of December, are very regular, giving a symmetrical graph, with its mode in the first half of February. Graph 7, *b* shows that class I (80–99 ft.) is dominant, having constituted 53·6 p. c. of the total catch ; and that class II comes next, with 32·4 p. c. While this season at S. Georgia agreed with the one previously considered in the importance of these two classes, the resemblances in the numbers killed go no further. At the S. Shetlands 1925/26, Blue Whales (of all classes together) were most numerous in December and April, and were remarkably few in February and March. At S. Georgia 1921/22, these whales were only moderately numerous in December, reached their highest points in January and February, with no great fall in March, and were very few in April. Their monthly incidence was, in fact, almost inverse to that in the other season and locality.

A comparison of Graphs 5, *a* (p. 116) and 8, *a* (p. 123) shows that in both cases under discussion the season began with a prevalence of large Blue Whales. There is little difference between the frequencies, in the two seasons, of class I in November, December, and January ; but, while in the S. Shetlands season there was a steep fall in I after January and a nearly equally steep rise to April, the fall after January in the S. Georgia season was gradual to April and continued steeply to May. The graphs of II are almost alike, throughout the months, in the two seasons compared, except that May has not been represented in the S. Shetlands graph, as only 7 Blue Whales, all belonging to classes I and II, were killed. If these were added to Graph 5, *a*, both the May percentages (I, 57·1 ; II, 42·9) would appear slightly above the respective April levels. It is not possible to assume that correct percentages can be obtained from figures so small ; but it is interesting to find that making use of them results in an almost complete identity of the graphs for class II in the two seasons, from November to May. It has been remarked by the whaling Companies, moreover, that the return of large whales at the end of the season, after a month or two during which they have been uncommon, is of frequent occurrence. With regard to classes III and IV, Graph 8, *a* shows no resemblance to the S. Shetlands results.

Graph 8, *b* indicates a marked difference in percentage composition between May and the other months, but the total for May was only 31, and this number is too small to make it certain that the percentages represent the real facts. The other six months have a considerable resemblance to one another, the extreme differences in them between the highest and lowest percentages of the frequencies in any length-class being 15·7 in class I.

S. Georgia, 1921/22. *Fin Whale.* Total catch, 511 (Tables 11, 12, pp. 117, 118).

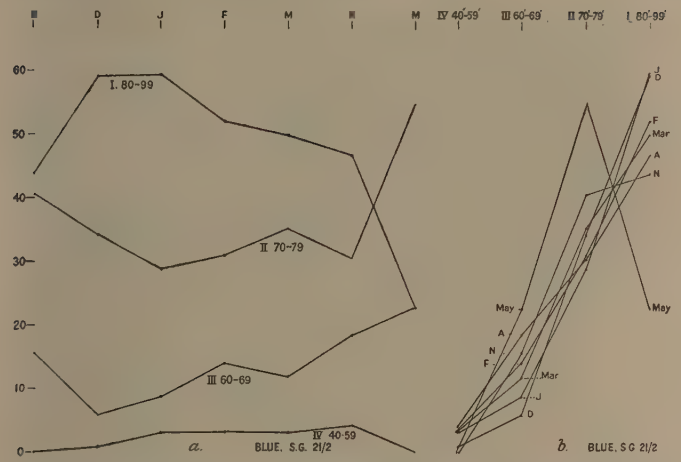
The total catch was small, and December, January, and May are the only months in which a reasonably large number of



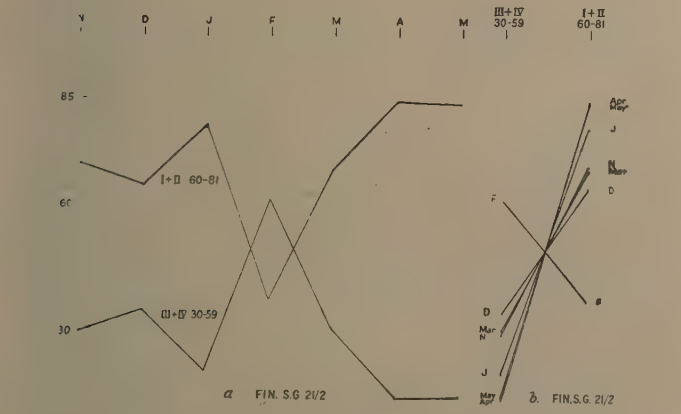
Graph 7.—S. Georgia, 1921/22. *a*, Fin Whale; *b*, Blue Whale. Total catch and monthly catches of three length-classes, in feet, as indicated. The figures are the actual numbers caught. N–M, November to May.

whales were killed. If the figures are analysed as in the preceding instance, the resulting graphs, when superposed, cross one another in a complicated way. I think this is partly because the numbers are too small, in certain months, to give a true record. I have accordingly simplified Graph 9 by combining I with II, and III with IV, to make two classes (60–81 ft. and 30–59 ft., respectively).

The season-graph (Graph 7, *a*) is bimodal, with a sharp peak in December, a marked depression in February and March, and a subsequent distinct rise through April to May. The length-classes (I, II and III + IV) representing the



GRAPH 8.—S. Georgia, 1921/22. Blue Whale. *a*, frequencies of four length-classes, in feet, as indicated, November to May (N–M); *b*, the same frequencies, in each month separately. Percentages, in total catch of the species in each month, in the margin.



GRAPH 9.—S. Georgia, 1921/22. Fin Whale. *a*, freque cies of two length-classes, in feet, as indicated, November to May (N–M); *b*, the same frequencies, in each month separately. Percentages, in total catch of the species in each month, in the margin.

actual numbers killed correspond in general form with that of the season-graph; but I + II strongly predominate in the catch, of which they constitute 72·6 p. c.

The contrast, in the Fin Whale, between Graphs 9 and 6 (pp. 123, 116), for the two seasons under comparison, is striking, especially when it is realized that if the two graphs had been drawn on the same principle, the combined class I + II in Graph 6, *a* would have been situated between the limits 86·1 and 94·3 p. c., and would have been widely distant throughout from classes III and IV. In the S. Georgia season (Graph 9, *a*) I + II is high at the two ends of the season, but is conspicuously low in February. III + IV is, of course exactly inverse to I + II.

Graph 9, *b* emphasizes the difference between February, in which the smallest whales were in marked excess, and the other months. The highest percentage of the largest whales is found in April and May, and it is interesting to note that the graph for April, although the total catch for this month was only 39, coincides exactly with that for May, with a total of 103. In November class I + II is composed entirely (as shown by a more detailed analysis) of whales of 60–69 ft. (class II).

The Fin Whale stock at the S. Shetlands, 1925/26, was found to have remained unaltered during the whole season, individuals belonging to class II having been throughout in a great majority (63·8 p. c. of the total catch). At S. Georgia, 1921/22, an entirely different state of affairs occurred. Although the same class was predominant, it constituted only 42·8 p. c. of the total catch; and its relative numbers, in the several months, varied greatly. It must be noted, however, that the totals on which the percentages were calculated were specially low in November and in February to April. In the first three months (Nov.–Jan.) its percentage (II) exceeded those of all the other classes separately, and it was the largest constituent, in actual numbers, of the first mode of the season-graph in December. In February its percentage sank to 19·2, but in March it rose to 50·0, declining slightly in April and May, in both of which it was surpassed by class I. With this class it was mainly responsible for the second mode of the season-graph, in May.

It is suggested, in an official Report, that the small number of Fin Whales recorded in this season may have been due to the preferential catching of Blue Whales. It is also stated that there was a marked absence of Blue Whales in April and May, but that Fin Whales were abundant during these months. This evidence is important, as confirming in general the testimony of the graphs.

With regard to the relative proportions of the sexes, a point considered by Macintosh and Wheeler (1929, pp. 453–465), my analyses show that males were in a slight excess, constituting from 51 to 55 p. c. of the total, in the two species, at both localities (in the particular seasons which have been discussed). At the S. Shetlands the excess occurred in every month in the Fin Whale, and in all except October, January, and February in the Blue Whale. At S. Georgia, males were the more numerous in December, January, February, and May, in the Fin Whale; and in the same months, as well as in November, in the Blue Whale. So far as these figures go, there seems to be a tendency for males to be in excess at the

TABLE 13.—Blue Whale. S. Shetlands, 1925/26 and S. Georgia, 1921/22. Individuals of 90–106 feet, monthly captures.

	S. Shetlands, 1925/26.		S. Georgia, 1921/22.	
	Male.	Female.	Male.	Female.
Nov.	3	9	2	—
Dec.	12	24	11	23
Jan.	4	15	20	50
Feb.	—	1	14	44
Mar.	6	4	4	23
Apr.	10	20	—	7
May	—	—	—	1
Total ...	35	73	51	148

two ends of the season, in these localities. This is shown even in the case of the Fin Whale at the S. Shetlands, although this sex was in excess in all the months; since the percentage of males descended continuously from November to March, after which it increased to May.

The question of the maximum size reached by whales in the Antarctic area is of considerable interest; and Table 13 shows the recorded Blue Whales which exceeded a length of 89 ft. in the two seasons under consideration. It is noteworthy that graphs drawn from these figures would correspond closely, in both localities, with the respective season-graphs. Whether each sex is taken by itself or the two sexes are grouped together, the result is a bimodal graph with its peaks in December and

April, for the S. Shetlands; and a unimodal graph, with its peak in Jan./Feb., for S. Georgia. Agreements of this kind increase one's confidence in the value of the evidence afforded by the whalers' returns.

In the Whalebone Whales generally the female is known to be rather larger than the male. Table 14 shows that the largest Blue Whale recorded in these two seasons was a female of 106 ft.* (captured in April); and that the largest male was

TABLE 14.—Blue Whale. S. Shetlands, 1925/26 and S. Georgia, 1921/22. Individuals of 90–106 feet, numbers of each length.

Length in feet.	S. Shetlands, 1925/26.		S. Georgia, 1921/22.	
	Male.	Female.	Male.	Female.
90	16	37	23	58
91	2	5	7	22
92	4	10	7	17
93	4	4	2	20
94	1	4	1	5
95	3	3	3	12
96	1	1	3	5
97	1	2	3	6
98	1	1	1	2
99	1	2	1	1
100	—	3	—	—
104	1	—	—	—
106	—	1	—	—
Total	35	73	51	148

one of 104 ft. (caught in March). The large females were more than twice as numerous as the large males at the S. Shetlands, and nearly three times as many at S. Georgia. But if a female Blue Whale, on reaching its full length, were only two feet

* Risting, 1928, p. 29, states that this is the largest Blue Whale recorded in his statistics; and (p. 31) that the largest Fin Whale was a female of 87 ft. caught at the S. Shetlands in Jan. 1925.

longer than the corresponding male, the males which are to be compared with the females of 90 and 91 ft. would be respectively 88 and 89 ft. long, and would not appear in the table. If, then, the females of 90 and 91 ft. are subtracted from the totals shown, 42 must be deducted in the case of the S. Shetlands, and 80 in that of S. Georgia. The females really corresponding with the males of 90 ft. or more are thus reduced, respectively, to 31 and 68. The numerical preponderance of females of the largest size seems to be a simple result of the fact that they are actually larger when growth ceases, as at earlier times in their lives.

In the case of the Fin Whale, I have ascertained the number of specimens recorded as exceeding 79 ft. in length ; but the instances are too few to require tabular treatment. At the S. Shetlands, 1925/26, there were 18 of these individuals (5 males, 13 females). All were recorded as 80 ft., with the exception of 3 pregnant females captured in March. Two of these were 81 ft. ; and the third, of 86 ft., is the largest included in these returns. At S. Georgia, 1921/22, the only individuals above 79 ft. were 3 females ; 2 of 80 ft. (Feb., Mar.) and 1 of 81 ft. (Jan.).

Recent numbers of the Norwegian whaling journal (N.H.T. 1930, pp. 56, 93, 97) contain an important article by Risting on the conditions which affect the distribution of whales round S. Georgia. He states (p. 93) that there is a fairly good agreement between the water-temperature and the weather, a conclusion which justifies the use I make below of the air-temperatures. S. Georgia is said to be affected by the Brazil stream, which brings warm water to the island. This is counteracted by a cold northerly current coming from the south ; and there may be a sharply defined mixing zone of the two currents, to the N. of S. Georgia. The interacting effects of these currents exert an influence on the melting of the ice and thus on the growth of the plankton and on the occurrence of whales, which are concentrated along the ice-edge at the beginning of the season. The rapidity of the melting of the Antarctic ice depends largely on its constitution. If it consists mainly of the relatively light ice of the previous winter, melting takes place comparatively rapidly. This affects the position of the ice-edge, which is further south in some seasons than in others. S. Georgia was practically ice-free in its coastal water during the whole of the season 1928/29, for instance ; and only a few ice-fields passed by. When the progressive thaw opens the sea to the south, the whales follow and distribute themselves over the open sea further south. If the thaw begins early, as a consequence of the action of warm surface-water, the whales become scattered sooner than in a season with a late thaw.

A similar behaviour of the whales has been observed in connexion with the Ross Sea (N.H.T. 1930, p. 13), where the vessels are obliged to wait at the ice-edge until the thaw has progressed sufficiently to allow them to force a passage through the belt of pack-ice. The whales are also assembled along the outer edge of the pack-ice, where a considerable number may be caught at the beginning of the season. They travel further south when they, like the ships, are able to penetrate the pack. If the ships succeed in reaching the open water of the Ross Sea, where the best catch has usually been made, before the whales can do so, the numbers caught are at first small. Since the period at which the pack breaks up varies from year to year, the date on which operations can be commenced in the Ross Sea itself is also variable ; and the season is in any case short. In 1928/29, for instance (see also Marshall, 1930, p. 244), it did not begin till Dec. 24. The maximum catch of Blue Whales is naturally obtained rather later than that made along the northern edge of the ice-belt in the W. Antarctic. The number of Fin Whales caught inside the Ross Sea has always been small, and is indeed almost negligible.

My special object throughout has been to ascertain whether the statistics, both of captured whales and of monthly temperatures, would throw any light on migration. As I assume that the whales are largely indifferent to variations of heat and cold, it is perhaps not to be expected that there is a close correlation between their occurrence and the temperature at any locality. The real factor determining the arrival of a migration at a certain date may have to be sought in a far distant place, where the completion of the breeding season, the failure of the food supply, or some other cause may start the impulse which leads to the southward journey.

My attempts to find correlations have, to a large extent, had negative results ; but in one particular a correlation between whales and temperature is so obvious that no extensive statistics are required to prove it. So long as the waters in the far south are covered by an unbroken expanse of ice, the whales must be absent, because in these conditions they could not rise to the surface to breathe. I am informed by Mr. G. E. R. Deacon, of the ' Discovery ' Expedition, that the salinity of the water in the neighbourhood of S. Georgia and the S. Shetlands is from 33 to 34 per thousand. With this salinity the freezing-point of the water is from $-1{\cdot}79°$ to $-1{\cdot}84°$ C. which I express as from $28{\cdot}69°$ to $28{\cdot}78°$ F., for comparison with the mean monthly temperatures received from the Meteorological Office. Although these are presumably air-temperatures, they may be used as indications of the ice-conditions and water-temperatures in the same months. I assume that the ice will not break up completely so long as

the mean monthly air-temperature is well below 28·7° F., which I refer to as the "critical temperature."

In trying to find some correlation between temperature and the occurrence of whales, it seemed to me natural to suppose that a very cold winter would have the effect of postponing the breaking-up of the ice in the spring; and that the appearance of the whales would be later after such a winter than after a mild winter. I have come to the conclusion that little correlation of this kind exists. The lowest mean temperatures recorded at the S. Orkneys during the period for which I have figures are given in Table 15 for the three coldest and the three mildest winters; and the corresponding figures for S. Georgia are inserted for comparison. The Table emphasizes

TABLE 15.—South Orkneys and South Georgia. Cold and mild winters at S. Orkneys.

Lowest mean monthly temperatures. ° Fahr.

	Cold winters.			Mild winters.		
	1915.	1918.	1924.	1920.	1922.	1919.
South Orkneys ...	Aug. —0·4	Aug. 2·8	July 5·9	July 14·0	May 14·4 June 14·0 Aug. 14·5	May 16·5 June 16·7
South Georgia ...	Aug. 26·1	Aug. 24·1	July 27·1	June 27·3	May 28·9	May 28·0

the very great difference in climate between these two localities, which are not many degrees of latitude apart. In 1915 the minimum at the S. Orkneys was 26·5° lower than at S. Georgia. The lowest mean monthly temperatures at S. Georgia, in these six years, are all below the freezing-point of fresh water, but those of the three milder winters are slightly nearer the critical temperature. I have been unable to detect any common characteristics which distinguish the catch of whales during the three seasons which respectively follow the cold winters from that of the seasons next after the mild winters. The minimum winter temperature of the air in the far south seems to have little to do with the catch of whales, as its effect may be counteracted by relatively high water-temperatures in the succeeding months.

It seems possible, on the other hand, to establish some correlation between the September mean air-temperatures at S. Georgia and the peculiarities of the whaling seasons at the

same locality. Table 16 gives the mean monthly temperatures for the S. Orkneys and S. Georgia. February is statistically the warmest month and July the coldest, in both localities; although, as shown in Table 15, the actual minimum may occur in May, June, July, August (or even September), in either of them. On arranging these mean monthly temperatures as graphs, I find, as would be naturally expected, that there is a moderately close correlation between the two localities; but that, at S. Georgia, changes from month to month are usually less abrupt and the graphs have the projections to some extent reduced. The minimum temperatures are usually, but not always, in the same month, in the two localities. The most striking difference noticed was in the year 1923. At the S. Orkneys the September minimum of 10·8° rose

TABLE 16.—South Orkneys and South Georgia.

Normal mean monthly temperatures. ° F.

	Jan.	Feb.	Mar.	Apr.	May.	June.
S. Orkneys	32·2	32·7	31·1	26·6	18·9	14·9
S. Georgia	41·0	41·9	40·1	36·3	32·2	29·3

	July.	Aug.	Sept.	Oct.	Nov.	Dec.
S. Orkneys	12·9	14·5	19·6	25·2	28·0	30·6
S. Georgia	28·8	29·1	32·5	34·9	37·4	38·8

abruptly to 26·4° in October. At S. Georgia, in the same year, the August minimum of 26·6° rose by gradual stages to 39·4° in January 1924.

Table 16 shows that the statistical September temperature at the S. Orkneys is 19·6°; and the actual variations during the period 1913–1925 have been from 10·8° to 23·7°. September is thus always well below the critical temperature, and the ice presumably does not begin to break up before October at the earliest. The statistical temperature of this month is 25·2°, although in 1918 it was 31·1° F. The whaling season begins in November or December. The difference between the normal mean temperatures of the two localities is greatest in the winter (July), and it decreases fairly regularly, in both directions, to midsummer (December, January), where it is less than 9°. If this approximation to the S. Georgia temperatures did not occur, whaling would not be possible at the S. Orkneys.

As a result of a careful study of these figures I have come to the conclusion that there is a definite correlation between the September mean temperature at S. Georgia and the order in which the Blue Whale and the Fin Whale reach their maxima, during the whaling season which commences immediately

TABLE 17.—S. Georgia, S. Shetlands, and S. Orkneys. Correlation of occurrences of Blue Whale and Fin Whale (see p. 147).

	Season.	Sept. mean temp. at S. Georgia 0° F.	Earlier maximum at S. Georgia.	Correlation, S. Georgia and S. S. *or* S. O.	Higher percentages of total, Blue+Fin.		
					S. Georgia.	S. Shetlands	S. Orkneys.
I	1927/28 ...	27·0	Blue	Inverse	Blue, 60·8	Fin, 54·0	Blue, 51·5
I	1917/18 ...	29·1	„	„	„ 65·2	„ 59·0	
I	1926/27 ...	29·8	„	„	„ 76·2	„ 73·1	Fin, 51·4
I	1923/24 ...	32·0	„	„	„ 58·4	„ 52·9	Blue, 72·3
I	1922/23 ...	32·4	„	„	„ 70·8	Blue, 50·2	Fin, 75·8
I	1924/25 ...	32·4	„	„	„ 63·7	Fin, 54·1	„ 62·6
II	1928/29 ...	32·9	Blue } Fin }	Inverse	Fin, 66·6	Blue, 62·8	Blue, 81·7
II	1919/20	33·6	Blue } Fin }	Direct	„ 61·2	Fin, 63·6	
II	1925/26 ..	30·4	Fin	Direct	Fin, 75·6	Fin, 52·6	Fin, 92·9
II	1914/15 ...	32·9	„	„	Blue, 55·6	Blue, 51·7	„ 74·5
II	1918/19 ...	33·1	„	„	Fin, 56·1	Fin, 60·9	
II	1920/21 ...	33·1	„	„	„ 75·1	„ 59·3	Fin, 87·7
II	1916/17 ...	33·3	„	„	Blue, 59·4	Blue, 69·6	
II	1921/22 ...	33·4	„	„	„ 78·2	„ 54·5	
II	1913/14 ...	34·2	„	„	Fin, 68·6	Fin, 58·7	Fin, 94·3
II	1915/16 ...	35·2	„	„	„ 59·8	„ 56·1	

afterwards, at S. Georgia (Table 17). The September temperature is of importance because it is closely connected with the events which lead to the melting of the ice. The seasons may be arranged, in the ascending order of their September temperatures, in three groups, which I distinguish as follows.

In Group I the maximum catch of the Blue Whale precedes that of the Fin Whale, at S. Georgia; and the September temperature is less than 32·5° F., the statistical mean temperature of the month. In Group II the maximum catches of the two species have been made in the same month; and the September temperatures have been slightly higher (32·9° to 33·6°). In Group III the Blue Whale maximum is later than that of the Fin Whale; and the September temperature is 32·9°, or higher. 1925/26, which I place in this group, is exceptional in having had a September temperature of only 30·4°. In a year with a September temperature near 32·9° the Blue Whale may precede or follow the Fin Whale, or may reach its maximum in the same month with it.

I use this grouping of the seasons in the sequel, and it is remarkable how often it gives consistent results—a fact which leads me to believe that the September mean temperature has a real bearing on some of the problems connected with Antarctic whaling.

In the case of a year with a bimodal season-graph, in either species, there are two peaks to choose from, but I think I have chosen fairly in taking the principal peak for comparison. In 1915/16 the December peak of the Fin Whale is so specially pronounced that I have thought it justifiable to select it, although it is actually 2·5 p. c. lower than the second peak in March.

The Meteorological Office figures show that the September mean temperatures at S. Georgia arrange themselves in groups of consecutive years. In 1913 to 1916, 1918 to 1921 and 1928, this figure was above the normal of 32·5° F. In 1917 and 1922 to 1927 it was below the normal. The Blue Whale maximum has accordingly preceded that of the Fin Whale mostly in the more recent years; and the Fin Whale has been first mostly in the earlier years.

I have no complete explanation to offer with regard to the seasonal movements of Antarctic whales, but I think some light is thrown on the subject by the assumption that in general the central point of the principal concentration of the Fin Whale lies somewhat to the north of that of the Blue Whale. It is obvious that these areas overlap, because the two species are caught simultaneously at all the whaling stations, and in most of the months of the season. Risting has stated (see pp. 127, 128) that at the beginning of the season the whales are concentrated along the northern edge of the pack-ice, into which they penetrate as soon as it begins to break up, with the approach of summer. He is not perfectly explicit on the subject, but the statement seems to refer principally to the Blue Whales, which prefer the neighbourhood of the ice.

If this is so, the Blue Whales would be well to the south of the Fin Whales, at the commencement of the whaling season, as they would be forcing their way into the open passages between the ice-floes which had been separated from one another by the commencing thaw. The Fin Whales do not appear to have this habit (see p. 108). The concentration of the whales facilitates the operations of the whalers ; but when the animals become dispersed over wider areas, after the disappearance of the ice, they are less easy to find, or even

TABLE 18.—Non-Antarctic localities. Blue Whale and Fin Whale. Annual catch, form of season-graph (B=bimodal; U=unimodal), usual months of maximal catch.

Locality.	Seasons.	Blue Whale.			Fin Whale.		
		Annual catch.	Graph.	Maxima.	Annual catch.	Graph.	Maxima.
Ross Sea	1926/27 to 1928/29	342–1,349	U	Jan., Feb.	39–88	U?	Jan., Feb., Mar.
Cape Colony, 34° S.	1922 to 1928	505–1,021	U or B	June–Oct.	276–796	B	May–Aug., Oct., Nov.
Walvis Bay, 22°–23° S.	1924 to 1927	155–316	U	Aug.	7–81	U or B	May, June, Oct.
Angola, 15° S. ...	1924 to 1927	75–303	U	July to Sept.	17–73	U or B	May, July, Aug., Sept.
Congo, French, 1° S.	1926	1	?	Aug.	—	—	—
Natal, 30° S.	1922 to 1928	98–240	U	June to Aug.	163–430	U	June, July.
Chili, 40° S.	1921/22	85	U	Feb./Mar.	21	?	?
Australia, W., 22° 40′ S.	1925 to 1928	0–5	?	Sept., Oct.	—	—	—

disappear ; and the catch declines. Risting states that they wander further south, especially into the Weddell Sea ; but there is evidence (see p. 108) that they may move N. or N.E. before they commence their main northward journey.

It may safely be assumed, as is universally done, that a generally northward movement of the whales takes place on the approach of winter, and that a return southward journey commences after the worst of the winter has passed. A certain amount of information with regard to the main

concentrations of the two species may be obtained from a study of the maximal catches made in the months of the whaling seasons at various localities. At the more northern stations, for instance (see Table 18) those on the W. coast of Africa, the maxima are in months suitably correlated with those of the Antarctic season. The Ross Sea is the most southern limit at which whaling has been carried out, or is indeed possible. Marshall (1930, pp. 245, 246) records the capture of whales in that sea, between 72° 40′ and 75° 9′ S., in the season 1928/29, in which the total catch of 3 floating factories consisted of 1,995 Blue Whales and only 57 Fin Whales, 17 Humpbacks, 1 Sei Whale, and 2 Sperm Whales (N. H. T. 1929, pp. 325, 328). 68·6 p. c. of the Blue Whales were caught in January and February (from monthly figures of two of the factories); and it may be added that in the same two months 74·5 p. c. were obtained in 1926/27, and 58·7 p. c. in 1927/28. In the same three seasons the total number of Fin Whales ranged from 39 to 88; 78·4 p. c. in January and February 1927/28; 89·7 p. c. in February 1928/29: and the entire catch in January to March 1926/27. These figures show that Blue Whales occur in large numbers in these extreme southern latitudes in January and February; and that Fin Whales are much less numerous, being most frequent from January to March. The greatly inferior number of Fin Whales indicates that their principal concentration is further north than that of the Blue Whale.

If I have understood Risting correctly (see p. 127), the ice-edge may be far to the north, even at the beginning of a comparatively warm season, provided that it consists of thin ice frozen in the previous winter and kept in existence by cold surface water. It may occur in much the same position in seasons in which the ice consists mainly of heavy pack-ice which is not merely the result of the previous winter's freezing. So long as the unbroken ice-edge exists in a locality, whales and especially Blue Whales are caught there in large numbers. If its position, at the beginning of the season, is near S. Georgia, Blue Whales will be caught there first, and in excess of Fin Whales, during the early part of the season. I assume that the main concentration of the Fin Whale has meanwhile been further north; and that they, too, go southwards in due course, but rather later than the Blue Whale. The main concentration will thus begin to reach S. Georgia as the Blue Whales depart.

It is not too much to say that the lines of migration of the two species are almost unknown. They appear in various parts of the Antarctic Ocean in quantities which are far greater than those found in any other locality. While their numbers are commonly reckoned in thousands at S. Georgia and the S. Shetlands, they are generally caught in hundreds in other

whaling fields (Table 19). The most prolific southern whaling ground, outside the Antarctic area, is Cape Colony. The largest total, of the two species together, included in my records is 1,779 in 1927, as compared with 10,093 in 1926/27 for S. Georgia with the S. Shetlands and the S. Orkneys. There are no whaling stations on the E. side of S. America; and the amount done on the W. side is hardly more than

TABLE 19.—Cape Colony and Natal. Blue Whale and Fin Whale, totals for seasons and maximal catches. When the season-graph is not unimodal, the lower peaks are in brackets. When two months are indicated as a maximum, the month with the greater catch is in italics.

Season.	Cape Colony. Totals and maximal catches.		Natal. Totals and maximal catches.	
	Blue.	Fin.	Blue.	Fin.
1927 ...	1,021. May/*June*.	758. (June), Aug.	221. June/*July*.	291. June/*July*, (Sept.).
1926 ...	997. June,(Sept.).	796. June, (Aug.), (Oct.).	209. July.	338. July.
1923 ...	669. (May-July), Sept.	460. (May), (July), Oct.	210. July/*Aug*.	331. June.
1922 ...	614. (July),Sept.	276. (June), Oct.	98. June.	163. July.
1924 ...	505. Aug.	570. (June), Oct.	169. July.	353. June.
1928 ...	554. *July*/Aug.	436. (May-July), Oct./*Nov*.	131. July.	430. *June*/July.
1925 ...	783. July,(Sept.).	694. (May), July.	240. June/*July*.	254. June.
1918 ...	105. Aug.	150. (Apr.), June, (Aug.)	11. July.	60. July.
1920 ..	125. (July), Oct.	134. (June), Nov.	71. *June*/July.	159. June.

negligible. It appears probable that, during the southern winter, the whales are scattered over large areas of the oceans, including those parts of the Antarctic which are not ice-bound; and that the Atlantic component is composed principally of individuals which do not travel south in close proximity to the great Continents.

It may be further supposed that a second large component comes from the west, through Drake Straits *, to the S. of Cape Horn. I venture to suggest that the geographical position of S. Georgia, just N. of 55° S., nearly in the same latitude

* See the account given by Hardy (1928, pp. 220–222) of the relation of S. Georgia to the drift travelling eastwards through Drake Straits.

as Cape Horn, may have a very important bearing on the frequencies of the whales caught there.

As shown by the Ice Chart (No. 1241) published by the Admiralty in 1874, the northern limit of the area in which icebergs may occur during the southern summer reaches lat. 40° S., well to the N. of S. Georgia. A little W. of the island it turns S., passing the Falkland Is. near their E. coast and, continuing W., S. America very near Cape Horn. Within this iceberg-frequented area lies S. Georgia, which has open water all through the southern winter ; and also the S. Shetlands and the S. Orkneys, which are ice-bound at that time and in the early spring. The only part of Drake Straits which is normally free of summer icebergs is a narrow belt off Cape Horn. The position, in this Strait, of the ice-edge, which is so important a factor in the consideration of the whales, no doubt varies with the years ; but it may probably be assumed that when the water is specially cold at the beginning of the season, it will be cold enough to discourage the Fin Whales from traversing the greater part of Drake Straits to any large extent. If this component of the Fin Whale stock is an important one, its absence at the beginning of the season will materially affect the numbers caught at the Antarctic stations.

The Blue Whales presumably have a much less obstructed passage through the Straits, at this time, because of their preference for the neighbourhood of ice : and this stream of Blue Whales will be reinforced by others coming from the Atlantic or from the Antarctic to the E. of Graham Land. The Blue Whales will, in cold years, be in a majority at S. Georgia, at the beginning of the season, and they will arrive there before the Fin Whales. For the same reason the western component of the Blue Whales would be added to the stock which arrives from other directions at the S. Shetlands and the S. Orkneys, early in the season : and the Blue Whale would be in a majority, at this time, in these localities also.

Continuing to assume that, at this period of the year, the Fin Whale concentration lies to the N. of that of the Blue Whale, it follows that, with varying seasons, it might occur to the N. of S. Georgia, in the latitude of that island, or to the S. of it. In a cold season, that is, one with a low September mean temperature, the ice-edge would be relatively far to the N., and the Blue Whale would at first be in a majority in all the Antarctic whaling fields, the Fin Whale not having yet arrived in any great quantity, even at S. Georgia. In a milder season the Fin Whale concentration is assumed to be near the latitude of S. Georgia ; and this species would be the first to arrive there, though not at the two " Southern localities," a term which I use below, for the sake of brevity, in referring to the S. Shetlands and the S. Orkneys.

Table 20 is constructed to show the usual sequence of the maximal monthly catches at the three stations. The Southern localities (S. L.) are treated as if they were a single complex, in which sometimes one and sometimes the other is in advance, the complex maintaining, however, a characteristic position in the sequence. My general conclusions are as follows.

The Blue Whale reaches its maximum first at all three localities, except in certain seasons, belonging to Group III (Table 21, p. 138). In these years the Fin Whale has been first, at S. Georgia alone, and it has been succeeded there by the Blue Whale at the Southern localities. I explain this exception by assuming that, at the beginning of the seasons in question. the main concentration of the Fin Whale has been in or near

TABLE 20.—Blue Whale (B) and Fin Whale (F). Typical sequence of monthly maxima of the seasons at S. Georgia (S. G.), and the complex S. Shetlands and S. Orkneys (S. L. = Southern localities).

Group I. ...	B, S. G. *or* B, S. L.	B, S. L. *or* B, S. G.	F, S. G.	F, S. L.
„ II. ...	B, S. L.	{ B, S. G. } { F, S. G. }	—	F, S. L.
„ III. ...	B, S. L. *or* F, S. G.	F, S. G. *or* B, S. L.	B, S. G.	F, S. L.

the latitude of S. Georgia, the Blue Whales being near the ice-edge and further to the S. This condition should occur in seasons which are relatively warm at the beginning, or, in other words, in those belonging to Group III (Table 17). In these seasons it would be a matter of chance which would be the first maximum ; in some it would be the Fin Whale at S. Georgia, but in others it would be the Blue Whale at the Southern localities, or at least at one of them.

A striking fact brought out by Table 20 is that, whatever be the order in which the other maxima occur, the last maximum is practically always that of the Fin Whale at the Southern localities. This is presumably due to the fact that the Blue Whales disperse, to a considerable extent, after the New Year, many of them following the retreating ice-edge. The Fin Whale does not go so far south, and it is thus left in principal possession of the field, during the latter half of the season, in all three localities.

In Group I the first maximum is alternatively South Georgia or the Southern localities, the Blue Whale in either case, This offers no special difficulty, since it may be supposed that if the main concentration of this species is in some latitude intermediate between S. Georgia (just N. of 55° S.) and the

Southern localities (S. of 60° S.), the question which will have the earlier maximum will be an open one. If the concentration is so situated as to be more favourable for S. Georgia, this

TABLE 21.—Blue Whale (B) and Fin Whale (F). Actual sequence of the monthly maxima of the seasons at S. Georgia (S. G.), the S. Shetlands (S. S.), and the S. Orkneys (S. O.). The lower peak of a bimodal season-graph is given in brackets. Where two months are indicated as a maximum, the month with the greater catch is in italics.

1927/28 ...	B., S. G., Nov.	B., S. S., *Nov.*/Dec.	B., S. O., *Nov.*/Dec.	F., S. G., Dec./*Jan.*	F., S. O., Feb.	F., S. S., *Feb.*–Apr.
1917/18 ...	B., S. G., *Dec.*/Jan.	B., S. S., *Jan.*–Mar.		F., S G., (Oct./*Nov.*) Jan./*Feb.*		F., S. S., Mar.
1926/27 ...	B., S. S., Nov. (Mar.).	B., S. O., Nov./Dec. (equal).	B., S. G., Dec./*Jan.*	F., S. G., (Nov.) Jan.–*Mar.*	F., S. O., Jan.–Mar.	F., S. S., *Mar.*/Apr.
1923/24 ...	B., S. G., Dec.	B., S. S., Dec.	B., S. O., Jan. (Mar.).	F., S. G., *Jan.*/Feb.	F., S. S., Feb.	F., S. O., Feb.
1922/23 ...	B., S. G., Dec. (Mar.).	B., S. S., Dec./*Jan.*	B., S. O., Dec./*Jan.*	F., S. G., Jan.	F., S. O., *Jan.*/Feb.	F., S. S., Mar.
1924/25 ...	B., S. G., Dec.	B., S. S., Jan.	B., S. O., Jan.	F., S. G., Jan.	F., S. S., Jan. (Mar.).	F., S. O., Feb.
1928/29 ...	B., S. O., Nov./*Dec.*	B., S. S., *Dec.*/Jan.	B., S. G., Jan.	F., S. G., (Oct.) Jan.	F., S. O., Feb.	F., S. S., *Feb.*/Mar.
1919/20 ...	B., S. S., *Dec.*/Jan.		B., S. G., Jan.	F., S. G., Jan.		F., S. S., Jan.
1925/26 ...	B., S. S., Dec. (Apr.).	F., S. S., Jan. (Mar.).	B., S. O., Jan.	F., S. G., Jan./Feb. (equal).	B., S. G., (Oct.) Feb./*Mar.*	F., S. O., Mar.
1914/15 ...	B., S. S., Dec.	F., S. G., Dec.	B., S. G., Jan.			F., S. S., Jan.
1918/19 ...	F., S. G., Oct. (Jan.).	B., S. S., Dec./*Jan.*	B., S. G., Jan.			F., S. S., Feb.
1920/21 ...	B., S. S., Dec./*Jan.*	F., S. G., *Jan.*/Feb.	F., S. S., *Jan.*/Feb.		B., S. G., (Nov.) *Mar.*/Apr.	
1916/17 ...	F., S. G., Jan.		B., S. G., Feb.			
1921/22 ...	B., S. S., Dec.	F., S. G., Dec. (May).	B., S. G., Jan./*Feb.*			F., S. S., Mar.
1913/14 ...	B., S. S., Dec.	F., S. G., Dec.	B., S. G., Jan.			F., S. S., Jan.–Mar.
1915/16 ...	F., S. G., (Dec.) Mar.	B., S. S., Jan.	B., S. G., *Jan.*/Feb.			F., S. S., Feb./Mar.

locality will come first ; and *vice versa*. The second maximum is naturally that of the Blue Whale at the locality at which it was not first. If S. Georgia was first, it was probably due to the fact that, at the beginning of the season, the Blue Whale concentration was near that island. By a shift southwards,

slightly later, it would be transferred to the Southern localities, which would have the second maximum. If the Southern localities come first, it seems necessary to assume that, on the break up of the ice-edge, further south, some of the Blue Whales migrate N. to S. Georgia. Evidence has been given, on p. 108, that a movement in this direction has been actually observed.

The third maximum, that of the Fin Whale at S. Georgia, in Group I, seems to be explainable as a consequence of the southward migration of the whole complex of whales, as the season advances. Most of the Blue Whales will have disappeared from S. Georgia at about the middle of the season; and the Fin Whales, which at first were N. of the island, will have taken their place as the predominant species.

The next general conclusion to be drawn from Table 20 is that, while in Group I, with relatively low September mean temperatures, all the Blue Whale maxima precede all those of the Fin Whale, there is a tendency, with increasing September temperatures, for the S. Georgia Fin Whale maximum to be shifted towards the beginning of the season. Group II is intermediate in this respect, this maximum being moved to the second place, where it is simultaneous with that of the Blue Whale at the same locality. In Group III, with the highest September temperatures, the S. Georgia Fin Whale maximum may come first; or if it is not first, it is second. This is in contrast with the behaviour of the Blue Whale, which, as a first maximum at S. Georgia, is confined to Group I.

The sequence of maxima in Group III is explainable on the assumption that, in these seasons, the ice-edge was further south than in those of Group I, the Blue Whale concentration being thus near the Southern localities and that of the Fin Whale near S. Georgia (at the beginning of the season). In these circumstances it will be an even chance which maximum will come first; and the one which does not occupy that place will come second. The third maximum, Blue Whale, S. Georgia, seems to require, as before, the assumption that, on the dispersal of the Blue Whales, some of them move N. to S. Georgia, reinforcing those which have remained there or are arriving from other directions. The immature individuals, probably arriving from the north, which make their appearance at about the New Year, are probably also important in this connexion.

In Group II, which occupies an intermediate place, the Blue Whale, Southern localities, maximum has the first place, and the second maximum is simultaneous for the two species at S. Georgia. The Group consists of only two seasons, and the number is so small that no conclusions can be drawn with confidence from it.

As already pointed out, the last maximum is practically always the same, for all three localities.

The exceptions to the general statements already made are not numerous : and they may be ascertained from Table 21 (p. 138). In deciding the sequence of the maxima, it is frequently necessary to take account of half months ; and for this purpose I have counted a clear maximum in November, for instance, as preceding a maximum in a class consisting of the second half of November and the first half of December. In the case of a bimodal season-graph, where the order is determined by the principal peak, the month of the lower peak is given in brackets. It must further be noted that in certain seasons (*e.g.*, 1924/25) two or more maxima have occurred in the same month ; but I think it is not unfair to arrange these cases of equality in the order which corresponds best with that indicated by the majority of the other seasons in the same Group.

With this qualification there are no exceptions, in Groups I and II, to the sequence indicated in Table 20. In Group I the Blue Whale, S. Georgia, maximum was first in four seasons, and was simultaneous with the Blue Whale, S. Shetlands, maximum in 1923/24. The Blue Whale, Southern localities, maxima were slightly before the other in 1926/27.

In Group III the Blue Whale, S. Shetlands, maximum was simultaneous with that of the Fin Whale, S. Georgia, in three seasons (1914/15, 1921/22, and 1913/14), all in December : but these need not be considered exceptions. For 1916/17 the only figures are those from S. Georgia, and there is nothing to indicate how these would have compared with the Southern localities. The Fin Whale graph, S. Georgia, 1915/16, is bimodal, and the slightly lower December peak was selected as the important one (see p. 132). If this is permissible, the season is not exceptional. 1918/19, which is not exceptional, was remarkable, at S. Georgia, for having had an actual maximum, in a bimodal graph (Fin Whale), in October. It is unique in this respect, but 1928/29 (Group II) has a subordinate peak in the same month ; and 1917/18 (Group I) has a similar peak in Oct./Nov.—in both cases bimodal graphs of the Fin Whale at S. Georgia. The earliest maxima of the Fin Whale, in Group III, with the exception of 1918/19, have been in December, at S. Georgia. In nearly all seasons of this Group, but not in 1925/26, the Fin Whale at S. Georgia has been second if the Blue Whale at the S. Shetlands has been first ; and *vice versa*. 1925/26 is exceptional in the early maximum of the Fin Whale at the S. Shetlands, where it was simultaneous with the Blue Whale at the S. Orkneys ; and it barely preceded the Fin Whale at S. Georgia. 1920/21 was also exceptional in having the Fin Whale, S. Shetlands, in advance of the Blue Whale, S. Georgia. It is noteworthy that the Blue Whale graph of this season at S. Georgia resembled

that of the preceding exception (1925/26), at the same locality. These two graphs were unlike any others, having a moderate secondary peak in either November or October, falling distinctly for two months, and then rapidly rising to the principal peak in Mar./Apr. and Feb./Mar., respectively. This unusually late maximum disturbed what I regard as the normal sequence in the case of 1920/21, but it was not entirely responsible for the failure of 1925/26 to conform with the general rule.

TABLE 22.—South Georgia, excesses (actual numbers).

	Sept.–Dec.		Jan.–May.		June to August.	Total.	
	Blue.	Fin.	Blue.	Fin.		Blue.	Fin.
1927/28 ...	860	—	—	246	—	614	—
1917/18 ..	434	—	30	—	F., 1	463	—
1926/27 ...	1,364	—	1,159	—	—	2,523	—
1923/24 ...	495	—	57	—	—	552	—
1922/23 ...	1,509	—	768	—	—	2,277	—
1924/25 ...	1,120	—	388	—	—	1,508	—
1928/29 ...	—	285	—	1,275	—	—	1,560
1919/20 ..	—	208	—	338	—	—	546
1925/26 ...	—	430	—	3,445	—	—	3,875
1914/15 ..	—	168	425	—	F., 2	255	—
1918/19 ...	—	99	—	141	F., 2	—	242
1920/21 .	—	242	—	1,526	—	—	1,768
1916/17 ...	65	—	257	—	B., 10	332	—
1921/22 ...	113	—	1,198	—	—	1311	—
1913/14 ...	—	560	—	206	—	—	766
1915/16 ...	—	262	—	317	F., 15	—	594

1920/21 is the only season, of the entire series, in which the Blue Whale maximum at S. Georgia has been the latest of all.

Table 21 thus shows that, on the whole, the Blue Whale comes first in the whole sequence of maxima, and the Fin Whale last. The two species are actually caught in the same months, in practically all cases, but the monthly excesses of one species over another require consideration. If the season be divided into two halves, Sept.–Dec. and Jan.–May, it will

be seen from Tables 22–24 that the Blue Whale has been in excess, in the first half, in all seasons at the S. Shetlands, in all but 1925/26 (with a trifling excess of 8 Fin Whales) at the S. Orkneys, in all seasons of Group I at S. Georgia, and in two seasons of Group III in which there was a total excess of Blue Whales. The Fin Whale has been in the majority, in the second half, in all seasons at the S. Shetlands, in 5 out of 7 at the S. Orkneys, in both seasons of Group II at S. Georgia, and in 5 out of 8 in Group III. Except at S. Georgia the Blue Whale is typically predominant in the first half of the season and the Fin Whale in the second half.

TABLE 23.—South Shetlands, excesses (actual numbers). (No detailed records for 1913/14, 1914/15 and 1916/17.)

	Sept.–Dec.		Jan.–May.		June to August.	Total excess.	
	Blue.	Fin.	Blue	Fin.		Blue.	Fin.
1927/28 ...	1,172	—	—	1,496	—	—	324
1917/18 ...	1	—	—	155	—	—	154
1926/27 ...	175	—	—	2,344	—	—	2,169
1923/24 ...	617	—	—	791	—	—	174
1922/23 ...	511	—	—	496	—	15	—
1924/25 ...	274	—	—	571	—	—	297
1928/29 ...	1,941	—	—	628	—	1,313	—
1919/20 ...	119	—	—	621	—	—	502
1925/26 ...	562	—	—	778	—	—	216
1914/15 ...	?	?	?	?	—	117	—
1918/19 ...	158	—	—	454	—	—	296
1920/21 ...	360	—	—	1,123	—	—	763
1916/17 ...	?	?	?	?	—	778	—
1921/22 ...	801	—	—	532	—	269	—
1913/14 ...	?	?	?	?	—	—	620
1915/16 ...	188	—	—	701	—	—	513

The seasons are commonly referred to by the whalers as either " Blue Whale years " or " Fin Whale years," specially when the excess of the species indicated is a marked one

Tables 22–24 show that the nature of an excess is in general different at S. Georgia and the Southern localities. With respect to the two halves of the season, an excess at S. Georgia is typically cumulative and at the Southern localities it is usually subtractive. In 14 seasons out of 16 at S. Georgia (Table 22), the excess in the number of either the Blue Whale or the Fin Whale in the first half is followed by an excess in the same direction in the second half ; and, in Group I, the earlier excess of the Blue Whale is always the greater. In Groups II and III, with the exception of the Fin Whale in 1913/14, the earlier excess of either the Fin Whale or the Blue Whale is the smaller. These results are mainly the natural consequence

TABLE 24.—South Orkneys, excesses (actual numbers).
(No detailed records for 1913/14, 1914/15 and 1920/21.)

	Oct.–Dec.		Jan.–Apr.		May to August	Total excess.	
	Blue.	Fin.	Blue.	Fin.		Blue.	Fin.
1927/28 ...	1–5	—	—	108	—	17	—
1926/27 ...	117	—	—	134	—	—	17
1923/24 ...	61	—	69	—	—	130	—
1922/23 ...	15	—	—	177	—	—	162
1924/25 ...	39	—	—	166	—	—	127
1928/29 ...	304	—	47	—	—	351	—
1925/26 ...	—	8	—	521	—	—	529
1914/15 ...	?	?	?	?	—	—	181
1920/21 ...	?	?	?	?	—	—	43
1913/14 ...	?	?	?	?	—	—	451

of the fact that the Blue Whale is predominant in the first half of the season, at S. Georgia, in Group I, and the Fin Whale is generally in the majority in the second half, in Groups II and III.

In 1914/15, 1916/17, and 1921/22 (S. Georgia, Group III) the Blue Whales are in excess in the total catch. In the last two this species was in excess in both halves of the season, and the second excess was the greater, as in the case of the Fin Whale in Group III. In 1914/15 the excess of the Blue Whale in

the second half of the season was sufficiently large to counterbalance what may be regarded as a normal excess of the Fin Whale in the first half. In 1921/22 the season-graph of the Blue Whale rises to an actual maximum in February, although January is not far inferior to it (Graph 3, *b*, p. 114). In 1916/17 there is a sharp peak in February, the ascending part of the graph showing a small irregular depression in December ; and the half-monthly figures show poor results in the second half

TABLE 25.—South Georgia, Blue Whale and Fin Whale, percentages of total catch of each species in the two halves of the seasons. Captures in June–August are not included.

	Sept.–Dec.		Jan.–May.		Total catch.	
	Blue.	Fin.	Blue.	Fin.	Blue.	Fin.
1927/28 ...	82·0	49·5	18·0	50·5	1,708	1,094
1917/18 ...	61·2	32·6	38·8	67·4	993	529
1926/27 ...	46·9	31·2	53·1	68·8	3,670	1,147
1923/24 ...	51·3	35·9	48·7	64·1	1,927	1,375
1922/23 ...	50·7	28·8	49·3	71·2	3,886	1,609
1924/25 ...	49·9	31·5	50·1	68·5	3,501	1,993
1928/29 ...	52·5	35·4	47·5	64·6	1,564	3,124
1919/20 ...	30·1	33·0	69·9	67·0	944	1,490
1925/26 ...	21·2	14·3	78·8	85·7	1,842	5,717
1914/15 ...	30·0	54·2	70·0	45·8	1,268	1,011
1918/19 ...	53·6	50·8	46·4	49·2	869	1,109
1920/21 ...	23·8	17·1	76·2	82·9	876	2,644
1916/17 ...	34·2	40·6	65·8	59·4	1,040	718
1921/22 ...	17·5	40·0	82·5	60·0	1,822	511
1913/14 ...	21·5	49·4	78·5	50·6	651	1,417
1915/16 ...	29·2	34·6	70·8	65·4	1,136	1,715

of December and the first half of January. This may perhaps have been due to bad weather ; and an official Report on the season states that the weather generally was stormy, the ice-conditions bad, and whales were scarce. The significant fact seems to be that the Blue Whale maximum was for some reason

TABLE 26.—South Shetlands, Blue Whale and Fin Whale, percentages of total catch of each species in the two halves of the seasons.

	Sept.–Dec.		Jan.–May.		Total catch.	
	Blue.	Fin.	Blue.	Fin.	Blue.	Fin.
1927/28 ...	78·0	11·8	22·0	88·2	1,830	2,154
1917/18 ...	0·4	0·0	99·6	100·0	349	503
1926/27 ...	52·2	14·0	47·8	86·0	1,261	3,430
1923/24 ...	56·8	10·8	43·2	89·2	1,378	1,552
1922/23 ...	34·0	4·9	66·0	95·1	1,752	1,737
1924/25 ...	31·5	12·4	68·5	87·6	1,644	1,941
1928/29 ...	64·7	6·9	35·3	93·1	3,198	1,885
1919/20 ...	30·5	7·3	69·5	92·7	672	1,174
1925/26 ...	42·4	14·9	57·6	85·1	2,166	2,382
1918/19 ...	32·5	1·6	67·5	98·4	527	823
1920/21 ...	41·5	13·7	58·5	86·3	1,666	2,429
1921/22 ...	50·3	1·0	49·7	99·0	1,619	1,350
1915/16 ...	21·7	9·0	78·3	91·0	1,845	2,358

TABLE 27.—South Orkneys, Blue Whale and Fin Whale, percentages of total catch of each species.

	Oct.–Dec.		Jan.–Apr.		Total catch.	
	Blue.	Fin.	Blue.	Fin.	Blue.	Fin.
1927/28 ...	61·7	21·0	38·3	79·0	298	281
1926/27 ...	63·4	20·9	36·6	79·1	284	301
1923/24 ...	32·3	8·6	67·7	91·4	211	81
1922/23 ...	39·5	6·3	60·5	93·7	76	238
1924/25 ...	29·8	5·4	70·2	94·6	188	315
1928/29 ...	68·1	4·0	31·9	96·0	452	101
1925/26 ...	18·2	2·8	81·8	97·2	44	573

later than usual (Table 21, p. 138). This species, while being in slight excess in the first half of each of the two seasons, was in much larger excess in the second half; in both cases the maximum monthly catch and the largest excess of Blue over Fin Whales occurring in February. 1914/15, the third Blue Whale year in Group III, agrees with the majority of seasons in having had an excess of Fin Whales in the first half. This was entirely due to a specially large catch (400) of this species in December (Table 33, p. 158), producing an excess over the Blue Whale, in that month, of 218. I cannot suggest any plausible explanation of these three Blue Whale years in Group III. It will be seen, however, from Table 28 (p. 148) that there is a considerable resemblance in the monthly excesses, in the three years, except for the fact that the 1921/22 season began exceptionally late, and its catch was negligible up to the end of November. In all of them the Blue Whale retained its pre-eminence throughout most of the months of the season, to the end of April. The catch for this year has been described, in some detail, on pp. 121–124.

It follows from what has been said above, illustrated by Table 22 (p. 141), that at S. Georgia, with the few exceptions noted, the species which is first in excess nearly always maintains its superiority in both halves of the season and in the total catch. Blue Whale years, at this locality, occur in Groups I and III; Fin Whale years in Groups II and III.

In the Southern localities (Tables 23, 24, pp. 142, 143) it is the general rule that the Blue Whale is predominant in the first half of the season and the Fin Whale in the second half. There are three exceptions in the S. Orkneys; but, owing largely to the special difficulty of whaling in this locality, the figures are here very irregular in the different seasons. They need not, therefore, be held to prove that the S. Orkneys are essentially different, in this respect, from the S. Shetlands. At the S. Shetlands the Fin Whale excess, in Group I, is large enough to counterbalance the earlier Blue Whale excess, except in 1922/23, where the total excess of Blue Whales is so small that it hardly disproves the general rule. The two seasons in Group II give different results, 1928/29 having been conspicuously a Blue Whale year, and 1919/20 a well marked Fin Whale year. In Group III, in which there are no monthly figures for three of the seasons, the Fin Whale excess of the second half of the season is greater than the Blue Whale excess of the first half, in 4 out of the 8 seasons; but in 1921/22 the result is reversed. The other 3 show a final Blue Whale excess, and they are the seasons which were exceptional, in the same respect, at S. Georgia.

In considering the monthly excesses (Tables 28–31, pp. 148–151), it is natural to find that the greatest differences in the

numbers of the two species will generally occur when, at any locality, the Blue and Fin Whale maxima are in different months. The simultaneous occurrence of the two maxima in the same month will result in a comparatively small excess of one of the species.

The differences between S. Georgia and the Southern localities are in many ways so marked that there seemed reason for looking into the question whether favourable conditions for either species at S. Georgia might not coincide with unfavourable conditions at the two other localities. On tabulating the facts, arranging the seasons on the basis of the earlier maximum at S. Georgia, in the ascending order of the September mean temperatures, I obtained the striking result shown in Table 17 (p. 131). An inverse correlation of the kind anticipated appears really to occur, but it is almost confined to the seasons of Group I. In Group III the correlation was found to be direct; and Group II showed its intermediate character by having one season with inverse and one with direct correlation. The exceptions, which are singularly few, are as follows :—

1927/28. S. Orkneys. Correlation direct, but the excess of the Blue Whale is only 3 p. c.

1923/24. S. Orkneys. Correlation direct. The excess of the Blue Whale is marked, but the total catch of the two species together was only 292.

1922/23. S. Shetlands. Correlation direct, but the excess of the Blue Whale is only 0·4 p. c.

1914/15. S. Orkneys. Correlation inverse, the total catch of the two species having been 369.

The exceptions are thus entirely in the irregular figures of the S. Orkneys, based on a small total catch, except in one season at the S. Shetlands, where the excess in the direction not anticipated is negligible.

The years in which either species has had a total catch of 2000 or more have been entered in Table 32 (p. 152); and these are the most striking cases which have occurred. Four seasons are represented by two localities. In 1926/27 (Group I), a well-marked Fin Whale year at the S. Shetlands, with large actual numbers and a high percentage of the dominant species in the total catch, is inversely correlated with a similar Blue Whale year at S. Georgia. 1928/29 (Group II) is like that season, but the inverse correlation is between a Fin Whale year at S. Georgia and a Blue Whale year at the S. Shetlands. 1920/21 and 1925/26 (Group III) are instances of direct correlation between Fin Whale years at the two localities; and the latter is noteworthy as having had the largest catch (5,717 Fin Whales) ever made of either species in one locality.

TABLE 28.—Blue Whale and Fin Whale. The excess (actual number) of one species over the other is given for each month and for the total catch. The excesses of the Blue Whale are in italics.

SOUTH GEORGIA.

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Winter months.	Total.	Species in excess
1927/28 ...	*2*	*205*	*419*	*234*	17	145	76	9	*1*	—	*614*	Blue
1917/18 ...	*9*	*16*	*141*	*268*	*171*	33	26	75	7	Aug. 1	*463*	„
1926/27 ...	—	*226*	*386*	*752*	*712*	*380*	*136*	70	*1*	—	*2,523*	„
1923/24 ...	—	*31*	*89*	*375*	*218*	*67*	90	99	39	—	*552*	„
1922/23 ...	—	*274*	*484*	*751*	*75*	*168*	*376*	*149*	Eq.	—	*2,277*	„
1924/25 ...	Eq.	*43*	*412*	*665*	90	*61*	*215*	*121*	*81*	—	*1,508*	„
1928/29 ...	38	480	*40*	*193*	318	578	282	98	*1*	—	1,560	Fin.
1919/20 ...	*25*	57	70	106	15	118	189	16	—	—	546	„
1925/26 ...	*34*	*27*	68	423	1,117	874	331	693	430	—	3,875	Fin.
1914/15 ...	—	*33*	*17*	218	*218*	*164*	*51*	*10*	18	June 3 / *Aug. 1*	*255*	*Blue.*
1918/19 ...	79	131	*8*	*103*	*38*	78	64	33	4	June 4 / *Aug. 2*	242	Fin.
1920/21 ...	5	*27*	79	185	676	530	133	107	80	—	1,768	„
1916/17 ...	12	*25*	*90*	38	6	*195*	*39*	*33*	4	*July 1* / *Aug. 9*	*332*	*Blue.*
1921/22 ...	—	—	1	*114*	*362*	*502*	*353*	*53*	72	—	*1 11*	„
1913/14 ...	—	44	60	456	132	*59*	133	—	—	—	766	Fin.
1915/16 ...	*3*	*46*	46	275	*184*	*70*	354	137	80	June 45 / July 5 / *Aug. 35*	594	„

In all the seasons indicated in Table 32 the rule indicated above, with regard to correlation, is followed, with the single exception of 1922/23, alluded to on p. 147, as disregarding the rule by a hardly appreciable percentage excess of Blue Whales at the S. Shetlands.

TABLE 29.—Blue Whale and Fin Whale. The excess (actual number) of one species over the other is given for each month and for the total catch. The excesses of the Blue Whale are in italics.

SOUTH SHETLANDS. (No records for 1913/14, 1914/15, and 1916/17.)

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total excess.	Species in excess.	Correlation with S. Georgia.
1927/28	*3*	*160*	*583*	*426*	158	476	366	496	—	324	Fin	Inverse
1917/18	—	—	—	*1*	*72*	37	112	78	—	154	,,	,,
1926/27	—	*77*	*335*	237	429	478	643	789	5	2,169	,,	,,
1923/24	—	—	*179*	*438*	*16*	487	188	132	—	174	,,	,,
1922/23	—	—	*116*	*395*	*222*	196	336	186	—	*15*	*Blue*	Direct
1924/25	—	*22*	*177*	*75*	131	*74*	326	188	—	297	Fin	Inverse
1928/29	—	*304*	*687*	*950*	*478*	431	348	327	—	*1,313*	*Blue*	Inverse
1919/20	—	—	—	*119*	322	191	92	16	—	502	Fin	Direct
1925/26	—	*6*	*229*	*327*	369	263	466	*316*	*4*	216	Fin	Direct
1918/19	—	—	—	*158*	25	332	75	22	—	296	,,	,,
1920/21	—	—	*85*	*275*	181	624	318	—	—	763	,,	,,
1921/22	—	—	*59*	*742*	*276*	259	501	48	—	*269*	*Blue*	,,
1915/16	—	—	*44*	*144*	*343*	405	639	—	—	513	Fin	,,

In view of the preference of the Blue Whale for the neighbourhood of the ice, it might have been anticipated that this species would be in excess at the Southern localities more frequently than at S. Georgia. This has not been the case; and, as shown by the present series of records, the Blue Whale

has been in the majority in 9 seasons out of 16 at S. Georgia (Table 22, p. 141), in 3 out of 10 at the S. Orkneys (Table 24), and in 5 (for two of which there are no monthly figures) out of 16 at the S. Shetlands (Table 23). The apparent paradox that the Blue Whale, which specially frequents the ice, is most often in excess at the more northern locality (S. Georgia) is presumably to be explained by the assumption that its stay, in the largest numbers, at the two Southern localities is

TABLE 30.—Blue Whale and Fin Whale.

SOUTH ORKNEYS. (No detailed records for 1913/14 to 1921/22.)

Explanation as in Table 29. (No catch in Sept. and May.)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total excess.	Species in excess.	Correlation with S. Georgia.
1927/28 ...	8	*77*	*56*	*3*	109	*2*	4	*17*	*Blue*	Direct
1926/27 ...	—	*89*	*28*	45	32	57	—	17	Fin	Inverse
1923/24 ...	—	*30*	*31*	*43*	10	*36*	—	*130*	*Blue*	Direct
1922/23 ...	—	—	*15*	64	73	40	—	162	Fin	Inverse
1924/25 ...	—	*8*	*31*	12	153	1	—	127	,,	,,
1928/29 ...	*48*	*114*	*142*	*74*	17	10	—	*351*	*Blue*	Inverse
1925/26 ...	—	—	8	134	163	202	22	529	Fin	Direct
1914/15 ...								181	,,	Inverse
1920/21 ...								43	,,	Direct
1913/14 ...								451	,,	,,

relatively short, the catch falling off in the second half of the season, and in any case being usually surpassed in number, during that period, by that of the Fin Whales, which have moved southwards. The larger number of Blue Whale years at S. Georgia is due, moreover, specially to the fact that all six seasons in Group I were definitely Blue Whale years and were thus favourable for the occurrence of this species at that locality.

There is no doubt that there has been a relation between the occurrences of the two species which can be described as either inverse or direct correlation; but what is the significance (if any) of the difference? It appears to me that the inverse correlation shown in the first 7 seasons in Table 17 (p. 131) is a fact of real significance; and that, in general, it is due to a fundamental difference of conditions between S. Georgia and the Southern localities. If this is so, the difference might be expected to produce a Fin Whale year at the Southern

TABLE 31.—Summary of monthly excesses of Blue Whales (B) and Fin Whales (F). The numerals indicate the number of seasons. Where a numeral stands by itself it represents all the seasons in which any catch was made in the month. In months in which one species has not always been predominant the numeral indicates the number of seasons in which the excess has occurred, and is followed by the number of seasons (in brackets) in which whales were caught. Equality between Blue Whales and Fin Whales is represented by $\frac{1}{2}$.

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
S. Shetlands	B 1	B 5	B 10	B 12(13)	F 7(13)	F 12(13)	F 13	F 10(11)	F 1(2)
S. Orkneys	—	B 1(2)	B 5	B 6(7)	F 4(7)	F 7	F 5(7)	F 2	—
S. Georgia, Group I.	B 2½(3)	B 6	B 6	B 6	B 4(6)	B 4(6)	B 3(6)	F 4(6)	B 3½(6)
S. Georgia, Group III. Blue Whales in excess.	F 1	B 32	B 2(3)	F 2(3)	B 2(3)	B 3	B 3	B 3	F 3
S. Georgia, Groups II, III, Fin Whales in excess.	F 3(6)	F 4(7)	F 5(7)	F 5(7)	F 5(7)	F 5(7)	F 7	F 6	F 4(5)

localities if S. Georgia had a Blue Whale year; and the correlation is thus inverse. In 1928/29 a different inverse correlation occurred, as S. Georgia had a well-marked Fin Whale year and the two Southern localities had a similar Blue Whale year. In both these localities the Blue Whales were in large excess in the first half of the season, but while this was added to in the second half at the S. Orkneys (Table 24, p. 143), an excess of Fin Whales in the second half did not counterbalance the earlier Blue Whale excess at the S. Shetlands (Table 23).

TABLE 32.—Blue Whale years and Fin Whale years.
Seasons in which the larger total exceeds 2,000.

Species in excess.	Locality.	Season and Group.	Total catch of the two species.		Percent. of total, Blue + Fin.		Correlation with	
			Fin.	Blue.	Fin.	Blue.	S. Shetlands.	S. Orkneys.
Fin Whale year.	S. Georgia	1925/26 III	5,717	1,842	75·6	24·4	Direct	Direct
,,	,,	1928/29 II	3,124	1,564	66·6	33·4	Inverse	Inverse
,,	,,	1920/21 III	2,644	876	75·1	24·9	Direct	Direct
							S. Georgia.	
,,	S. Shetlands	1926/27 I	3,430	1,261	73·1	26·9	Inverse	
,,	,,	1920/21 III	2,429	1,666	59·3	40·7	Direct	
,,	,,	1925/26 III	2,382	2,166	52·4	47·6	Direct	
,,	,,	1915/16 III	2,358	1,845	56·1	43·9	Direct	
,,	,,	1927/28 I	2,154	1,830	54·0	46·0	Inverse	
							S. Shetlands.	S. Orkneys.
Blue Whale year.	S. Georgia	1922/23 I	1,609	3,886	29·2	70·8	Direct	Inverse
,,	,,	1926/27 I	1,147	3,670	23·8	76·2	Inverse	Inverse
,,	,,	1924/25 I	1,993	3,501	36·3	63·7	Inverse	Inverse
							S. Georgia.	
,,	S. Shetlands	1928/29 II	1,885	3,198	37·2	62·8	Inverse	

But it must be remembered that the majority of all the seasons had a total excess of Fin Whales at the Southern localities, a fact probably due to the dispersal of the Blue Whales on the break-up of the ice and a movement of the Fin Whales southwards. If, then, any season has a Fin Whale excess at S. Georgia, it is more likely than not to have an excess of the same species at the Southern localities also, and the correlation will be direct. I have endeavoured to show, in the preceding pages, that differences between the seasons are connected with the immediately preceding September mean temperatures.

Three of the seasons do not completely agree with these generalisations, namely 1914/15, 1916/17, and 1921/22, in which the Blue Whale was in excess at S. Georgia as well as at the S. Shetlands (Tables 22, 23, pp. 141, 142). At the S. Orkneys, 1914/15 was the only one of these seasons represented, and Fin Whales were in excess. I have already stated (p. 146) that I am unable to account satisfactorily for these exceptions.

Throughout this discussion I have emphasized what seems to me the importance of the mean temperature in September; but I do not suggest that this in itself is the deciding factor influencing migrations. I presume that it gives some indication of the conditions in which the melting of the ice-edge takes place; resulting, with the interaction of oceanic currents, in the growth of the plankton on which the whales feed. The question is complicated by the fact that more than one line of migration converges on the Antarctic whaling fields. It is generally admitted that one component, both of Blue Whales and of Fin Whales, comes from a more northern latitude; and this is known to consist largely of immature individuals.

According to Ingebrigtsen*, "it is mainly the adult animals of both sexes that take part in the great breeding and food migration, whilst the younger animals are more erratic in their migrations." This statement is made in an account of northern Humpbacks, and I am not sure whether it is intended to have a more general application. It does not seem to apply completely to Blue and Fin Whales, since the southward migration of young individuals of these species to the Antarctic, at about the time of the New Year, appears to be an established fact. There is undoubtedly a nucleus of the two species left in Antarctic waters during the southern winter, and for some years they were regularly hunted at S. Georgia in all the winter months. Figures for this winter whaling are

* Ingebrigtsen, 1929, p. 9. See also Kellogg, 1929, pp. 485, 488, for the migrations of southern Blue and Fin Whales.

given in an Interdepartmental Report (Falkland Islands Report, 1920, p. 62), but no monthly figures are included, and they are accordingly not of much use in the present connexion. The only winter season of which I have an adequate record is 1916, June to September, and the numbers are very small (Blue Whales, 106 ; Fin Whales, 133). The percentages in the total catch of the smallest whales were very low : 9·4 for the Blue Whale (40–69 ft.) and 6·0 for the Fin Whales (30–59 ft.). The largest individuals were much more numerous : Blue Whales, 80–93 ft., 63·2 p. c. ; Fin Whales, 70–78 ft. 49·6 p. c. For those of intermediate size the percentages are : Blue Whales, 27·3 ; Fin Whales, 44·4. If these figures are typical, they show that the individuals which remain through the winter at S. Georgia are mainly those of large size, including more than 50 p. c. of sexually mature animals. In the Blue Whale the class of the largest individuals was greatest in all four months. This was also the case in the Fin Whales in June ; but the class of intermediate size was most numerous during July, August, and September. In both species the total catch was at its lowest in July, rising slowly in the case of the Fin Whale to September ; but in the Blue Whale with much the highest figure (57·5 p. c. of the total) in August, and only about one-third of this number in September. Other figures, for 1914–1918, suggest that the number of Fin Whales usually declines from May to its lowest point in August or even September ; except in 1918, with a very high percentage of the winter catch in September. This was the only year in which the maximum catch of the season Oct.–May occurred as early as October.

The only normal season, at S. Georgia, of which I have an analysis sufficiently detailed for comparison with the winter season of 1916 is 1921/22 (see p. 121). Whaling commenced, on this occasion, in November, so that October is not represented. It may be significant that this year agreed with the winter season of 1916 in the fact that in November, the earliest month of the season, the class of largest individuals had the highest frequency in the Blue Whale, and that of individuals of intermediate size in the Fin Whale. This evidence, slight though it is, indicates that the whales which winter in the Antarctic are (at least in certain years) principally adult or nearly adult individuals.

It seems probable that many, of the Blue Whales in particular, remain in the south during the winter, congregating in the spring along the ice-edge, and later dispersing over the waters further south ; a certain proportion, however, moving northwards. These winter residents are presumably joined by schools arriving from the breeding-grounds nearer the Equator. Some of these are fully adult, including lactating females,

accompanied by their young. Large schools of immature whales follow from the north and make their appearance on the whaling grounds at about the New Year, which is the season at which many of the adults disappear.

The migrations of the Fin Whale are even less certain. Some of them remain at S. Georgia during the southern winter, but there is little evidence that they stay in Antarctic waters in large numbers during this time. The facts contained in the whalers' returns seem to show that the Fin Whale is for the most part further north than the Blue Whale. It appears to move southwards, in considerable numbers, beyond S. Georgia, especially after the end of December, and to remain in the neighbourhood of the S. Shetlands and S. Orkneys, at least as late as March. It has not completely deserted S. Georgia, however, since numbers are caught there, simultaneously with those taken in the second half of the season at the Southern localities. The Fin Whale does not appear to travel southwards much beyond the latitude of the S. Shetlands ; and, at any rate, it enters the Ross Sea in restricted numbers. It presumably leaves the far south soon after March, sometimes re-appearing at S. Georgia late in the season, after which it vanishes into the unknown. In certain seasons at least a considerable percentage of the late arrivals at S. Georgia are of large size and have presumably come from further south.

The available evidence with regard to the breeding-seasons of the great whales has been derived mainly from a study of the lengths of fœtuses obtained at known dates. Hinton (1925), in his Report on the Barrett-Hamilton papers, came to the conclusion that, in the southern Fin Whale, the pairing season is principally from June to September (p. 63, n.), that its period of gestation is 10–12 months (p. 63), and that its length at birth is about 20 ft. (p. 119). The number of Blue Whale fœtuses which had been examined was small, but he concluded (p. 145), partly on the evidence of N. Atlantic fœtuses, that, although pairing in this species may occur in practically all months (as in the Fin Whale), the great majority of pairings are in a restricted period, which appears to correspond with that of the Fin Whale (p. 63, n.).

In 1928, Risting published a very important memoir, specially valuable as containing large numbers of dated fœtal records, mostly from the Southern Hemisphere. His general conclusions are closely similar to those of Hinton. The period of gestation, in both Blue and Fin Whales, is believed to be approximately 360 days (p. 93). He agrees that June to September is the principal pairing period for the Fin Whale (p. 100), and he states his opinion that the majority of Blue Whale pairings occur in June to August (p. 97). The length of the Blue Whale at birth is about 25–27 ft. (p. 92), and that of

the southern Fin Whale about 650 cm. (or 21 ft. 4 in.), the young being born at a somewhat smaller size in the northern Fin Whale (p. 107).

Macintosh and Wheeler (1929, p. 420) have referred to these and other papers on the subject; and their results, based on independent investigations, in which other lines of evidence are utilised, are very similar to those of Hinton and Risting. They conclude that in both species, in the south, the pairing season may extend over 7 to 8 months, but that May to August are the months in which it most frequently takes place, the maximum frequency being about the end of June or the beginning of July. There is no justification for the assumption that pairing may occur in any month (p. 427). The calf is born, on the average, about the beginning of the following May, "after the parent has made a southward migration to feed during gestation and returned to the warmer waters towards the north" (p. 437). The average length of the Blue Whale at birth is about 23 ft., and that of the Fin Whale about 21·3 ft. (p. 428). See also Risting 1929 (1–3).

I had myself made a preliminary study of a large number of northern and southern fœtal records, several years earlier, arriving at the result that in the large southern whales pairing takes place with maximum frequency from about July to September, and in the northern whales from about January to April. The short accounts published (Harmer, 1922 [1], 1922 [2]) contained a bare summary of my conclusions, without the evidence on which they were based.

The conclusions of different workers are thus mainly in agreement, and if they are even approximately correct, it follows, as has often been pointed out, that both pairing and parturition occur principally, in either Hemisphere, in months outside the ordinary whaling seasons, at localities distant from the Poles, and presumably in warm water (*cf.* Harmer, 1928, p. 82). The facts known with regard to the occurrence of whales off the African and American coasts support this view. Risting (1928, p. 35) has emphasized the fact that the average size of both Blue and Fin Whales captured on the African coasts decreases continuously from south to north. He finds that off Angola (lat. 15° S.) the percentage of the smallest class of Blue Whales is 90·4 of the total catch, and of Fin Whales, 97·4. Macintosh and Wheeler (1929, p. 454) state that small, immature whales, of either species, may constitute 80–90 p. c. of the catch off Cape Colony.

The maximal monthly catches for the African localities (Table 19, p. 135) are consistent with the view that both species migrate northwards to breed during the southern winter. The question thus arises whether any correlation can be established between Cape Colony and S. Georgia; and I

think this can be done, to some extent, so far as the positions of the two species in the several months are concerned. The Fin Whale season-graph at Cape Colony commonly shows two marked peaks, and occasionally three. In the corresponding Blue Whale graph the bimodal character (if the graph has this form) is generally less accentuated. In both species a peak may be found towards the end of the season. In 1922, 1923, 1924, and 1926 a well-marked peak occurs in October, in the case of the Fin Whale. In 1922, 1923, and 1926 a corresponding peak occurs in September in the Blue Whale graph, at the same locality. In 1920 and 1928 the Fin Whale graph rises from October to November, which has nearly 25 p. c. of the total catch in each year, and is always the last month of the season in all years. The Blue Whale has a definite peak in October in 1920, and a bare indication of a break in the rate of fall, in the same month, in 1928. In these six years the Blue Whale peak, towards the end of the season, is one month in advance of that of the Fin Whale. It can hardly be doubted that at this season both species are travelling southwards, and that the Blue Whale was one month further south than the Fin Whale in the years in question—a result which agrees with the relative positions of the species which I have assumed for S. Georgia. It is at least a striking coincidence that the four seasons in which the Fin Whale maximum is in October at Cape Colony belong to Group I of my S. Georgia classification—that in which the Blue Whale arrives first; and that the two seasons in which it occurs in November at Cape Colony belong to Group II or III. These facts suggest that if the Blue Whale leaves the latitude of Cape Colony immediately after the end of September (as indicated by the marked fall of the graphs in October), it is first on the ground at S. Georgia. If it leaves in November (supposing a correlation between the two localities to exist), it perhaps goes beyond S. Georgia, leaving the Fin Whale in its wake to become predominant at the beginning of the season at S. Georgia.

The concluding Tables (33–35) contain the detailed monthly figures (actual numbers) of Blue and Fin Whales in the Antarctic seasons here specially discussed: namely Table 33, S. Georgia; Table 34, S. Shetlands; and Table 35, S. Orkneys (pp. 158–160).

[*The Address has been largely re-written since it was delivered on May* 24.—S. F. H., Oct. 2, 1930.]

TABLE 33.—South Georgia. Actual monthly totals of Blue Whale (B) and Fin Whale (F).

Season.	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May.		Total.		
	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	
1913/14 ..	—	—	23	67	14	74	103	559	242	374	176	117	93	226	—	—	—	—	651	1,417	
1914/15 ...	—	—	62	29	136	119	182	400	457	239	191	27	136	85	51	41	53	71	1,269	1,014	*
1915/16 ..	13	—	74	28	102	148	142	417	287	103	273	203	108	462	81	218	56	136	1,221	1,815	*
1916/17 ..	21	33	43	18	164	74	128	166	215	221	305	110	93	54	57	24	14	18	1,051	719	*
1917/18 ...	21	12	84	68	213	72	289	21	264	93	69	102	46	72	6	81	1	8	995	532	*
1918/19 ..	17	96	104	235	148	140	196	93	256	218	91	169	43	107	11	44	3	7	880	1,122	*
1919/20 ...	42	17	19	76	89	109	184	290	393	408	160	278	101	290	6	22	—	—	944	1,490	
1920/21 ..	14	19	60	33	95	174	40	225	48	724	95	625	236	369	209	316	79	159	876	2,644	
1921/22 ...	—	—	—	—	82	33	286	172	484	122	528	26	369	16	92	39	31	103	1,822	511	
1922/23 ..	—	—	295	21	650	166	1,027	276	406	331	459	291	599	223	374	225	76	76	3,886	1,609	
1923/24 ..	—	—	119	88	266	177	603	228	483	265	315	248	77	167	58	157	6	45	1,927	1,375	
1924/25 ..	12	12	221	178	642	230	873	208	483	573	401	340	398	183	313	192	158	77	3,501	1,993	
1925/26 .	37	3	158	131	93	161	102	525	195	1,312	430	1,304	462	793	278	971	87	517	1,842	5,717	
1926/27 ..	—	—	288	62	566	180	867	115	929	217	562	182	393	257	62	132	3	2	3,670	1,147	
1927/28 ..	3	1	309	104	616	197	473	239	230	247	61	206	13	89	2	11	1	—	1,708	1,094	
1928/29 ...	9	47	57	537	287	247	467	274	556	874	77	655	93	375	16	114	2	1	1,564	3,124	

* These totals include a few whales captured in the winter months, June-August, as follows:—

	Blue.	Fin.		Blue.	Fin.
1914/15...	1	3	1917/18...	2	3
1915/16...	85	100	1918/19...	11	13
1916/17...	11	1			

TABLE 34.—South Shetlands. Actual monthly totals of Blue Whale (B) and Fin Whale (F).
(No monthly figures for 1913/14, 1914/15, and 1916/17.)

Season.	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May.		Total.	
	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.
1913/14 ...	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1,472	2,092
1914/15 ...	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1,796	1,679
1915/16 ...	—	—	—	—	49	5	350	206	764	421	499	904	183	822	—	—	—	—	1,845	2,358
1916/17 ...	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1,380	602
1917/18 ...	—	—	—	—	—	—	1	—	115	43	97	134	109	221	27	105	—	—	349	503
1918/19 ...	—	—	—	—	—	—	171	13	213	238	72	404	65	140	6	28	—	—	527	823
1919/20 ...	—	—	—	—	—	—	205	86	173	495	176	367	116	208	2	18	—	—	672	1,174
1920/21 ...	—	—	—	—	104	19	589	314	696	877	187	811	90	408	—	—	—	—	1,666	2,429
1921/22 ...	—	—	—	—	59	—	755	13	540	264	151	410	114	615	—	48	—	—	1,619	1,350
1922/23 ...	—	—	—	—	117	1	479	84	570	348	210	406	213	549	163	349	—	—	1,752	1,737
1923/24 ...	—	—	—	—	185	6	599	161	416	400	118	605	46	234	14	146	—	—	1,378	1,552
1924/25 ...	—	—	22	—	207	30	288	213	451	582	342	268	161	487	173	361	—	—	1,644	1,941
1925/26 ...	—	—	6	—	248	19	663	336	446	815	108	371	120	586	568	252	7	3	2,166	2,382
1926/27 ...	—	—	77	—	388	53	192	429	201	630	146	624	206	849	51	840	—	5	1,261	3,430
1927/28 ...	3	—	184	24	646	63	593	167	165	323	100	576	92	458	47	543	—	—	1,830	2,154
1928/29 ...	—	—	308	4	711	24	1,051	101	811	333	113	544	129	477	75	402	—	—	3,198	1,885

TABLE 35.—South Orkneys. Actual monthly totals of Blue Whale (B) and Fin Whale (F). (No records for 1915/16 to 1919/20, and 1921/22; no monthly figures for 1913/14, 1914/15, and 1920/21.)

Season.	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May.		Total.	
	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.	B.	F.
1913/14 ...	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	20	480
1914/15	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	94	275
1920/21 ...	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	7	50
1922/23 ...	—	—	—	—	—	—	30	15	32	96	11	84	3	43	—	—	—	—	76	238
1923/24 ...	—		—		34	4	34	3	71	28	27	37	45	9	—	—	—	—	211	81
1924/25 ...	—	—	—		8		18	17	103	115	26	179	3	4				—	188	315
1925/26 ..	—	—	—	—			8	16	12	146	10	173	9	211	5	27	—	—	44	573
1926/27 ...	—				90	1	90	62	41	86	37	69	26	83		—	—	—	284	301
1927/28 ...	—	—		8	102	25	82	26	73	70	17	126	22	20	2	6	—	—	298	281
1928/29 ...	—	—	48		114	—	146	4	88	14	48	65	8	18	—	—	—	—	152	101

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Adaptive Evolution, with special reference to Metamorphosis and Sex-limited Characters. By J. T. Cunningham, M.A.

[Read 9th January, 1930. See p. 28.]

In my volume on 'Hormones and Heredity,' published in 1921, I pointed out that there are two main problems of evolution, namely the Origin of Species and the Origin of Adaptations, and that Lamarck and Darwin and the majority of less eminent zoologists had treated these two problems as one. In other words, it has been assumed that species and, in a less definite way, varieties and geographical races differ from one another in characters which are adaptive and useful, excepting differences which may be due to the direct action of the environment and not to heredity.

Darwin seems nowhere to have attempted to show that particular specific characters are useful or adaptive. He states that variations neither useful nor injurious would not be affected by natural selection, but could be "either left in a fluctuating condition, or would become fixed owing to the nature of the organism or the nature of the conditions" *. The process suggested in the words quoted is not explained, but we have here an admission that some specific characters may be non-adaptive, though it is assumed that every species is differentiated by some difference of adaptation. This assumption has never been proved to be true. I pointed out in the volume mentioned that there is no evidence that peculiarities in the scales of Teleostean fishes, which form important diagnostic characters in classification, are useful or adaptive in the majority of cases, if in any.

In 1913 Bateson gave detailed evidence in birds, butterflies, and other animals that characters in local varieties and allied species are not generally adaptive. He expressed his conclusions very definitely, as the following quotations will show:— "We can disabuse ourselves of the notion that for all characters which are definite or fixed some utilitarian rationale may be present"; and "the theory of selection fails at exactly the point where it was devised to help: specific distinction" †.

Prof. D. M. S. Watson, in his presidential address to the Zoology Section of the British Association at the South African Meeting last year, maintained the same view. He referred to the lack of evidence that specific differences or physiological differences correlated with them are subject to natural selection, and stated that the characters have not been shown to be adaptive. But Prof. Watson was almost equally sceptical

* 'Origin of Species,' 6th edition, 1878, p. 63.
† 'Problems of Genetics,' 1913, p. 18.

about adaptation in general. He said that the suggestion that a character could be used for some definite function was too often regarded as evidence that it was so used. He repeated T. H. Morgan's suggestion that habit was probably often a consequence of structural characters which had arisen "casually," and not structure the consequence of habit. He admitted that the limbs of the single-toed horse were more efficient for locomotion than those of its three-toed or four-toed Eocene predecessors, but argued that while the paddle-shaped limbs of Ichthyosaurus were evidently adapted to an aquatic life, the hippopotamus, which is also aquatic, showed no such modification. It is obvious, however, that there is no close similarity between the habits of the hippopotamus and those of whales, to the limbs of which those of Ichthyosaurus are similar.

On the other hand, there can be no doubt of the existence or of the utility of great numbers of obvious structural adaptations in animals. The upright position in standing and the bipedal locomotion in the human species afford the most familiar example. The length and strength of the legs, the curvatures of the spine, the relations of the centre of gravity to the joints, the articulation of the head, all these structural details in which the human body differs from that of an ape are closely correlated to form a special mechanism adapted to the peculiar attitude and locomotion of man. In this case, if we hold that there is only one species which include several races, we have a conspicuous adaptation confined to a single species, but there is no certain proof that the characters by which the different human races are distinguished are also adaptive.

It is important to consider the word adaptation itself and what is implied or suggested by it. It is used in two senses, which are often confused :—(1) A structure, character, or mechanism which produces a special result, either by its action or by its mere existence, in the life of the animal, as, for example, wings are adaptations for flying, eyes for seeing, or a sandy colour for concealment in the desert. (2) The process by which an organ or an organism has been changed in the course of evolution in such a way as to become fit for new circumstances, new habits, or new functions. We have thus to study the uses of adaptations on the one hand, and their origin on the other. It is a familiar fact in zoology that a single type of animal or of organ presents numerous different forms which are adapted to different functions or modes of life. Thus the fore-limb of a vertebrate may be the fin of a fish, the leg of a reptile, the wing of a bird, the wing of a bat, the wing of a pterodactyl, or the arm of a man, all

these different forms except the fin being composed of corresponding or homologous elements. This feature in the evolution of adaptations is due to the continuity of reproduction and heredity; new individuals do not arise independently like tools and machines of human construction, but are produced from parents whose structural characters they, to a great extent, inherit. Therefore as evolutionists we have to explain how the primitive ancestral structure was modified and adapted to such different uses and different habits.

Recent research on reproduction and heredity has led to certain conclusions which are generally accepted among biologists, namely that characters consist for the most part of distinct units whose development depends on certain particles in the nuclear structures, called chromosomes, in the reproductive cells. These particles are termed genes. In fertilisation and development these genes and the characters to which they give rise come together and separate according to the Mendelian laws of heredity. New characters are observed to occur, and are attributed to changes in the genes which may be caused by chemical or physical agents acting on the reproductive cells, but are never due to external conditions acting on the body or soma. Such changes are called mutations, and the majority of biologists assume that all evolution is due to mutations and selection, the effects of external conditions being confined to the individual development and not changing the hereditary or genetic constitution. My object in this paper is to consider certain facts which seem to me to be inconsistent with these conclusions. The concept of mutation, based on observation and experiment upon cultivated varieties, agrees fairly well with what we know of the characters of varieties and species in the wild state, but even here it has not been found that in crosses between species the characters can always be analysed into units, following laws of Mendelism. With regard to adaptation, there are many facts which in my opinion cannot be explained by the doctrine of mutation and selection.

Prof. Watson's address, above mentioned, and the Hooker Lecture by Dr. E. J. Allen, given before this Society last March, are the two most recent general reviews of the subject of organic adaptation known to me. Both of them reject the direct action of external stimuli as the explanation of adaptation, and both of them entirely omit the consideration of certain subjects which are essential to the discussion of adaptation, and in which important advances have been made in recent times. These subjects are (1) Metamorphosis and Development, including Recapitulation, (2) Sexual Dimorphism, especially the relation of these phenomena to internal secretions.

Metamorphosis.

There is very good reason to believe that life originated in the water, and no change in evolution is more wonderful than the conversion of aquatic forms with aquatic respiration into terrestrial forms with atmospheric respiration. This transformation takes place at the present time in every individual frog or newt. There are many different conditions of development among Amphibia in general, ranging from the tadpole hatched in the water and spending some weeks or months in an aquatic existence, to complete independence of water within an egg-capsule or within the oviduct of the mother; but in all cases the young stage possesses gill-slits and gill-arches, and the various different modifications of the gill-processes are obviously secondary. In all cases the gill-slits and gill-arches are homologous with those of fishes, so that there can be little doubt that the free aquatic larva represents the original ancestral fish. After a certain period of growth the gill-slits of the larva or tadpole close up, the lungs develop as pouches of the gullet, the animal begins to breathe air at the surface of the water, and finally leaves the water and becomes terrestrial. The obvious and in my belief correct conclusion from the facts is that the lung-pouches developed originally in consequence of the habit of taking air into the œsophagus for respiration, in conditions such as stagnant water, high temperature, and rotting vegetation, which reduced the amount of dissolved oxygen in the water. According to the mutation theory the lungs developed as a mutation not caused by the breathing of air, but I know of no evidence whatever to support this assumption. There is very good reason to believe that all the bony fishes, all fishes except the cartilaginous sharks, rays, and chimæroids, are descended from fresh-water fishes which evolved lungs for breathing air. The most ancient fossil fishes were of this kind, and some of them survive to the present day, namely the Dipnoi and a few primitive forms such as the sturgeons, the American bony-pike, and the African Polypterus. In the fishes descended from these primitive forms the lungs have become the air-bladder, and there is no case known of any structure which might correspond to a pair of lungs having arisen by mutation independently of the habit of breathing air. Some ancestral fishes with lungs retained their gills and continued to live in the water, but the ancestors of the Amphibia after the lungs were developed became terrestrial and developed legs fitted for locomotion on land. It has been maintained by T. H. Morgan and W. Garstang that the larval amphibian does not recapitulate the adult stage of the ancestral fish, but only the larval stage of the ancestor; but it is a fact that the gills and gill-arches are adult structures of the fish and are

recapitulated as temporary organs in the frog or newt. The loss of the branchial structures and the development of lungs then must have taken place originally at a later stage of life, not at the beginning of development, and in correlation with changed conditions or habits, whereas mutations appear at the beginning of development and are independent of conditions.

The subject of the limbs in Amphibian metamorphosis need not be discussed in detail. We do not find a transition from fins to legs—the terrestrial limbs are developed directly. The tail, however, shows metamorphosis, the caudal fin disappears, the tail itself is absorbed in the Anura, becomes rounded in the Urodela. It is impossible to believe in this case that the change of structure arose casually, and that the animal was then driven to adopt the appropriate mode of life. The animal at the present day is often compelled by seasonal changes in temperature and in the oxygen content of the water to breathe air or perish, but there is no basis for the suggestion that it was forced to breathe air in consequence of the development of lungs and associated changes in heart and blood-vessels as mutations independent of external conditions. The prolongation of larval life when the aquatic conditions remain favourable occurs in many cases, and is termed neoteny. The experimental production of this extension of the aquatic phase has not been thoroughly investigated, but in the Mexican axolotl and other cases we have natural experiments resulting in restoration of the originally permanent aquatic mode of life and the elimination of the metamorphosis. It has been maintained that the neoteny of the axolotl is not hereditary, because the metamorphosis can be brought about experimentally, either by keeping the animal in moist air or by giving it thyroid gland-tissue as food. The latter fact, however, is evidence that the neoteny of the axolotl is more than the direct action of the conditions on the individual, because it produces its effect while the aquatic conditions remain unchanged.

This effect of thyroid feeding is of crucial importance in considering whether the mutation theory or the Lamarckian is more capable of explaining the evolution of adaption, especially in cases of metamorphosis. A single meal of thyroid at the proper stage of development will cause complete metamorphosis in the axolotl. When a little thyroid is added to the food of tadpoles they metamorphose precociously, and become abnormally diminutive frogs. On the mutation hypothesis, there is no reason why the special chemical compounds secreted by the thyroid gland should have these extraordinary effects. I know of no evidence that thyroid has any influence at all on mutations which have appeared in breeding experiments,

or in characters which are non-adaptive and may reasonably be attributed to mutation, as, for example, the rose-comb in the common fowl. On the Lamarckian hypothesis, the influence of thyroid in adaptive metamorphosis can be explained. Assuming that the quantity of thyroid secretion produced in proportion to the size of the body increases with age, and that the changes in the growth of parts which constitute the new characters were originally effected, and caused corresponding changes in the reproductive cells, in the presence of the increased proportion of thyroid secretion, it is possible that the inherited tendency to the development of the new characters would only become active in the presence of the proportion of thyroid secretion associated with the original formation of the characters by the action of external stimuli. The hereditary metamorphosis would therefore be associated with a certain amount of thyroid secretion in the tissues. When this amount was supplied artificially at an earlier age than the normal, precocious metamorphosis would be the result. The association, therefore, between thyroid and hereditary metamorphosis, on the hypothesis that the structural changes were originally due to the change from aquatic to terrestrial life, may be said to be analogous to a conditioned reflex, not suggesting, of course, that the processes are physiologically similar. It is not correct to say that the thyroid causes metamorphosis, except in the sense that it sets in action a latent inherited tendency. No amount of thyroid sets up metamorphosis in Amphibia like *Necturus*, in which aquatic respiration normally persists throughout life, nor in fishes. It has been suggested that the neoteny of the axolotl is due to a reduction in the size or activity of its thyroid gland, but this is disproved by the fact that thyroid of the axolotl, when administered to tadpoles, sets up precocious metamorphosis.

The metamorphosis of the respiratory organs in the evolution of terrestrial vertebrates, repeated in every generation of frogs and other Amphibia, is also repeated in the individual development of all the land vertebrates, Reptiles, Birds, and Mammals. Here also it is probable that the persistence of the hereditary succession of such different phases of development is due to the heredity of the influence of changes in the amount of thyroid and other internal secretions in the body.

The metamorphosis of the flat-fishes (Pleuronectidæ or Heterosomata) offers a somewhat different case in the fact that the structural change corresponds to a change of habit, not to a change of external conditions ; to a change of relation to the same environment, not to migration into a new environment. The fish lies on the ground at the bottom of the water in a position in which the original plane of symmetry is rotated through an angle of 90°. According to the mutation theory,

the change of structure, the asymmetrical position of the organs, especially of the eyes, arose or might have arisen casually, that is, by mutations which were entirely independent of the external conditions, and the fish was compelled to assume the horizontal position in consequence. The fact that the larva swims with its plane of symmetry vertical and is as symmetrical as the larva of other fishes, and becomes asymmetrical by gradual metamorphosis, indicates that the structural change was the consequence of the change of position, not the cause of it. On the theory of endogenous mutation, there is no reason why the adult should not develop directly without passing through the symmetrical condition of the ancestral form. The three chief adult characters are : (1) the position of the two eyes on one side of the head-region ; (2) the absence of pigment from the lower side, which is in contact with the ground when the fish is at rest, and always turned towards the ground ; (3) the extension of the dorsal and ventral fins along nearly the whole length of the body. Careful study of these characters shows that there is no internal correlation between them ; there is no physiological reason why the change in position of the eyes should be associated with absence of pigment from the lower side or with extension of the marginal fins. The two former characters are related to the direction of light, and the third to the undulatory movement of the fins as the fish glides along the bottom. One of the most remarkable facts about the asymmetry of the eyes is that the distortion which produces this change of position is limited to the interocular part of the skull and head, while the jaws and anterior part of the skull and brain on the one hand, and the posterior region of the skull and brain on the other, remain almost entirely unaffected. In several cases, as in plaice and sole, the jaws of the lower side are larger and stronger than those of the upper, while in other cases, as in turbot and halibut, the jaws are equally developed on both sides. In the rest of the body there is no distortion, but merely some difference in the development of the usual structures of the right and left sides, the lower side differing from the upper not merely in the absence of colour, but in the slighter development of the scales or other armature, and of the pectoral fin.

The study of flat-fishes seems to me to supply clear evidence against the modern suggestion that habit has been adapted to structure, and not structure to habit. The several modifications are all independent of each other, and only united by their relation to external conditions. It is incredible that the special distortion of the orbital bones, involving the bending of the interorbital septum to one side while the neighbouring parts of the skull and brain are scarcely affected, could have occurred as a mutation entirely undetermined by the changed

relation of the eyes to the direction of light. No instance of such a mutation, developing as a gradual change in an individual whose eyes were originally symmetrical, has been described among fishes swimming vertically. On the other hand, if the evolutionary change is attributed to selection, the mutations must be supposed to have occurred in a symmetrical fish which, after swimming vertically in the first period of its life, adopted the habit of lying on its side on the ground. But *ex hypothesi* the required mutations were no more probable after such a change of habit than in a fish which swam vertically, and it has yet to be shown that secondary changes towards asymmetry similar to those which take place in flat-fishes have ever occurred as endogenous mutations.

There is, however, actual evidence in abundance, in the occurrence of abnormal flat-fishes, of the kind of results which are produced by mutations unrelated to external conditions. Reversed specimens are common, more so in some species than in others. The chief importance of these, for my argument, is that the reversal only affects the external asymmetry, the eyes and colour being on the right instead of the left, or *vice versa*. In the normal Pleuronectid, whether the upper side is the right, as in plaice or sole, or the left, as in turbot or brill, the digestive organs are asymmetrical in position, the stomach and intestine being on the right and the liver on the left. In reversed specimens this internal asymmetry is quite unaffected. The digestive organs in the flat-fish are in the same relative and asymmetrical positions as in ordinary symmetrical fishes such as perch or cod. It is significant in considering the probability of the influence of external conditions in the evolution of these fishes that their asymmetry is strictly limited to those organs which are related to such conditions, namely eyes, colour of skin, and mouth. The pigmentation of the peritoneum follows that of the skin being on the upper side in all cases and absent from the lower side. Reversal of the positions of the internal organs occurs occasionally as a mutation in man and probably in other vertebrates, but the external asymmetry of the flat-fish is entirely independent of the asymmetry of the internal organs.

Still more important are the cases of ambicoloration, where part or all of the lower side is coloured and scaled like the upper, and the eye is on the edge of the head instead of being wholly on the upper side. The anterior end of the dorsal fin, which is usually continued forwards with its base attached to the edge of the head-region, in these abnormal specimens projects forwards freely as a hook-shaped process outside the eye belonging to the lower side, which is on the edge of the head instead of being on the upper side as in normal specimens. Such cases are especially frequent in the turbot, and present

slight variations in the degree of reversion to the symmetrical condition. There is no evidence that these abnormalities correspond to abnormalities of habit, but there is some evidence that the abnormal specimens lie on their sides at the bottom and partly bury themselves in the same way as normal specimens. The occurrence of various degrees of incompleteness and failure of the normal course of development is well known in many kinds of animals, and these are not correlated with special external conditions. In all probability the abnormalities in flat-fishes here considered are of the same kind, and are true mutations due to some change in the genes which determined their development. In that case it may be thought there is no reason why the original changes which gave rise to the normal flat-fish were not also mutations of endogenous origin. The reply to this is that the normal flat-fish develops in the individual by a continuous change from the symmetrical larva which repeats the symmetry of the ancestor, and therefore if the ambicolorate abnormality were of the same kind, it would develop first into the characters of a normal flat-fish and then undergo metamorphosis into the abnormal form by continuous change. There is no reason to suppose that this takes place, the ambicolorate form is a case of arrested development occurring as a mutation. It may here be mentioned that Bateson always insisted on the discontinuity of the evolution of species, and, as a fact, discontinuity is the essential in the concepts of unit characters and mutations. Adaptation, on the contrary, and especially adaptation associated with metamorphosis, is characterised by continuity. It is perhaps not always understood that the main question in the evolution of adaptations is not whether the doctrine of genes is true or not, but whether the effect of habits in modifying the relative growth of the body can be transmitted to the genes in the gametes, and so become hereditary. The abnormal specimens above mentioned show that the hereditary factors which control the normal development of the flat-fish are, like all hereditary factors, liable to mutations, and these mutations seem to show some reversion to symmetry.

It is necessary here to refer to the experiments carried out by myself many years ago which showed that prolonged exposure to daylight resulted in the development of pigment on the lower side of flat-fishes. These experiments afforded evidence that the absence of pigment from the lower side was due to the absence of light, but not merely as a direct effect on the individual. There was evidence of an inherited resistance to the development of pigment, which it required prolonged exposure to light to overcome. On the other hand, in ambicolorate specimens which occur in nature, the pigment which is present on the lower side is not, so far as we have evidence from living specimens, due to exposure of the lower

side to light. The logical conclusion from these facts is that in normal specimens the absence of light from the lower side has in the course of evolution produced a hereditary disappearance of pigment and resistance to its development.

The theory of T. H. Morgan and W. Garstang mentioned above with reference to the metamorphosis of the frog is applied also to the case of the flat-fish. It is maintained that the larval flat-fish does not resemble any adult fish, but only the larva of other fishes. It is perfectly true that the larval flat-fish does not possess all the characters of an adult symmetrical fish such as skeleton and scales in the fully-developed condition, but the flat-fish has never lost such characters; it possesses them in its adult condition. The important fact is that the larval flat-fish retains the symmetry of eyes and pigment which are characters not only of the larval stages, but of the adults in other Teleosteans. The dorsal fins in the great majority of Teleostean fishes terminate anteriorly at a point behind the eyes. The dorsal fin of the young flat-fish, even when the fin-rays are developed, terminates also behind the eyes except in one genus, and grows farther forwards after the lower eye has been brought round to the upper side. This is therefore the recapitulation of another adult character, persisting to the middle of the metamorphosis.

Sex-limited Characters.

(*Secondary Sexual Characters. Sexual Dimorphism.*)

Darwin himself realised that any theory of evolution must include an attempt to explain the origin of what are now called sex-limited characters, and he invented the theory of sexual selection as a necessary corollary to that of natural selection. But he pointed out very clearly that in all probability selection could produce differences between the sexes only by acting on variations which were originally limited in transmission to one sex. Sex-limitation, therefore, is not explained by the theory of sexual selection; it is a condition which must exist before that selection begins—not a consequence of it. Having been led by my studies of flat-fishes to a Lamarckian view of the origin of adaptations, I made a careful study of sexual differences to ascertain whether there was any evidence that sex-limited characters could also be attributed to external stimuli. With regard to structural characters, the evidence is abundant enough, and is detailed in my volume, published in 1900, with the title 'Sexual Dimorphism in the Animal Kingdom.' The subject of colour is more difficult; but more vivid colours appear to be related in some way to the greater sexual excitement of the male, especially in the breeding-

season. In the volume mentioned I proposed a somewhat vague theory of sex-limited heredity, namely that the functional activity of the testes has a profound effect on the rest of the body, especially in producing a state of nervous exaltation or excitement, and more rapid metabolism. The male structural characters, *e. g.* the antlers of stags, having been originally produced by external stimuli during this state, became sooner or later hereditary, but were only developed during the same condition in which they were acquired. This explained why they were developed only slightly or not at all in the female, and failed to develop normally in the male when the testes were removed, a fact which can never be explained by mere selection. A few years later it was discovered that the influence of the testes on the development of male secondary characters, whether temporary or permanent, was due to a special substance secreted by those organs—an internal secretion. The presence of this substance in the blood, and diffusing from the blood-vessels to permeate the tissues of the body, was therefore the secret of the special condition which I had previously postulated. Accordingly, I published in 1908, in my paper on "The Heredity of Secondary Sexual Characters in relation to Hormones," a theory of the heredity of secondary sexual characters and of their origin from the effects of external stimuli, this theory being extended into a general theory of the heredity of acquired characters. The general theory was derived from the special theory of the sex-characters. The theory may be described as a hormone theory of the origin of sex-limited characters in particular and of adaptations in general. On this theory the special growths of tissues or organs produced by external stimuli, whether mechanical or functional, give out special substances in the ordinary course of life and metabolism into the liquids circulating in the body, and these substances reach the reproductive cells and act upon the parts of those cells which correspond to the parts of the body whence the substances are derived. Whether on my theory or on the mutation theory, we must assume that there are special parts of the chromosomes of the gametes which determine the development of each part of the body, and we may use the term genes for these determinants as in the mutation theory. The hormones from the tissues stimulated to hypertrophy by external stimuli, *e. g.* an exostosis or an enlarged muscle, affect the corresponding genes in the gametes so that they tend to cause greater growth in the same tissues in the offspring. The effect is not perceptible in a single generation, but the accumulated effect after many generations produces the changes which constitute structural adaptation. The mutation theory gives no explanation of the influence of internal secretions

on the development of sex-limited characters. The contrast between cases which agree with the concept of mutation and those which agree with the Lamarckian concept is very obvious in the difference between sex-linked and sex-limited characters. The former, as for example red-blindness, can be explained on the assumption that it is due to genes situated in one of the chromosomes which determine sex, namely the one distinguished as the X chromosome, and that the Y chromosome which determines the male sex carries no character genes at all. Therefore a woman who has normal sight may carry the defect in a latent or recessive condition and transmit it to her sons, but a normal man cannot carry the defect as a recessive character; if he inherits the defect he is himself colour-blind, but transmits it only to his daughters. On the other hand, the genes of secondary sexual characters are equally present in both sexes, but develop only in the male because the presence of the hormone from the mature testis is necessary to their development. The female deer can develop antlers when sterile or when the ovaries are removed, and a stag cannot develop normal antlers after castration. There is nothing in all that is known about mutations which can explain this dependence of sex-limited characters on the hormones of the gonads. The explanation, according to my hormone theory, is that the effect of the hormones given off by the tissues stimulated to excessive growth was produced during the period in which the hormone of the functionally mature testis was present. The special genes controlling the tissues stimulated were therefore bathed in the hormones from those tissues and in the testis-hormone at the same time, and, in consequence of this, the modified development of the tissues concerned takes place only in the presence of the testis-hormone, and does not take place when the testis secretion is absent, and therefore does not occur completely in the female or in the immature male.

In the case of dimorphic birds such as the common fowl, castration does not prevent the development of the male plumage; but if ovarian tissue is implanted into the castrated male, the latter develops the female plumage. If the ovaries are removed from the female, she produces male plumage. Here we must conclude that the testis-hormone has less effect than in the mammal, perhaps because it is less chemically specialised or less concentrated than in the mammal; but the modified genes present in both sexes cannot develop in the presence of the ovarian hormone, which was never present when the genes were originally modified by the substances derived from the stimulated tissues.

All biologists are agreed that heredity is due to the chromosomes of the gametes, with the exception of a few cases in which the cytoplasm seems to have some influence. The

essential point of difference is whether the genes are entirely unaffected by the soma which contains them and nurtures them, and by the external conditions which admittedly affect and modify the soma. The geneticists admit the modification of genes by the ingestion of chemical compounds in Heslop Harrison's moths, although we are entirely in the dark concerning the mode in which the effect was produced, or the reason why certain salts should cause the gametes to produce dark pigment in the skin. It is equally possible that the specific chemical compounds in the internal secretions, or in the liquids of the body generally, should affect the genes so as to produce changes in structures or characters in development. It is also possible, if not certain, that external stimuli producing outgrowths of bone such as antlers, or growth of particular muscles through change of habit, should cause changes in the chemical composition of the body liquids which bathe the gametes as well as other cells of the body, and so cause modifications of the genes. The theory is that the chemical compounds derived from a hypertrophied tissue would cause a tendency to hypertrophy in the corresponding genes. These are matters of physiology and biochemistry, matters of experiment quite as much as genetics, and much important experimental work has been done on internal secretions in relation to metamorphosis and sex-limited characters.

Mutations occur in secondary sexual characters as in the adaptive characters of flat-fishes already mentioned, and in my opinion can easily be distinguished from the characters whose origin I attribute to external stimuli. There are certain breeds of fowl in which the plumage of the cock is like that of the hen, though the comb and other appendages of the head are still of the male type. It was found by T. H. Morgan and Goodale that when such hen-feathered cocks were castrated the next plumage developed after moulting was like that of a normal cock. There is no reason to suppose that the hen-feathered cock originated from any direct action of external conditions on the plumage. The reappearance of the male type of plumage after castration shows that the hen-feathering is due to the secretion by the testis of a hormone similar to that normally produced by the ovary, although the testis retains its male function. This is certainly a very extraordinary mutation, but there can be little doubt that the experimental result is due to the cause stated. The difference between the point of view of Mendelism and experimental biology is curiously illustrated by Prof. Punnett's discussion of this case: he remarks that normally the factor for the suppression of the cock type of plumage is transmitted by the hen to her daughters only. As this factor is shown experimentally to be the

hormone of the ovary itself, it could not be transmitted otherwise, but in the case of hen-feathered cocks the same hormone is secreted by the testis.

In a general discussion of sex-limited characters T. H. Morgan has suggested that they are the by-products of sexual hormones whose main function is to develop the greater strength and vigour of the male as compared with the female. This obviously does not throw any light on the subject. In the first place the sexual hormones do not produce the greater strength and vigour of the male; they only supply a condition necessary to the development of genes already present, and the greater strength and vigour of the male, where it exists, is itself a secondary sexual character whose origin has to be explained. In many cases, as in the birds of prey, it is the female which has the greater size and strength, and in many other cases, as in Columbidæ and kingfishers among birds, Rodents among mammals, there are no secondary differences between the sexes at all. We have experimental evidence that the internal secretion of the testis is similar in different animals, and that its action is to stimulate the development of the sex-limited characters peculiar to the animal in which it occurs or into which it is artificially introduced. Just as the thyroid of the sheep transforms tadpoles into frogs, not into lambs, so extract of the testis of the pig causes growth of the comb in castrated cocks. It can scarcely be doubted that the absence of antlers in the horse is not due to anything different in its testis secretion from that of the stag, but to the absence of any genes for antlers in the horse. There are thus two questions to be answered: (1) Why are such genes present in the stag and not in the stallion? (2) Why do such genes when present give rise to antlers only in the presence of the secretion of normal testes? Another important fact which must be taken into consideration and which is overlooked by the mutationists is that these characters have nothing essentially sexual in their nature. They are all special developments of the soma, and may affect any part of it whatever—teeth, skull, hair, tail-feathers, wing-feathers, general size, spurs on leg or wing in birds, fins of fishes, etc. They have no essential connexion with fertilisation or reproduction and in the majority of species are entirely absent. They correspond to differences of habit between the sexes and to the external stimuli arising from such habits. In stags and in horned ruminants the stimuli are the blows on the forehead inflicted by the males on one another, in the feathers of birds the movement of the quills when the feathers are erected in fighting or courtship irritate the papillæ from which the feathers grow. Many of the characters are not sexual but parental, as for example the milk-glands and placentation in mammals,

the former corresponding to the stimulus of sucking, and the latter to the parasitic action of the embryo within the oviduct in absorbing nourishment and oxygen from the maternal blood. The greater size and strength of the males where it occurs corresponds to the greater functional activity of the males in fighting. In stags and cocks the habit of fighting involves not only mechanical stimulation of bone or feathers or comb and wattles, but greater functional activity of muscles which causes hypertrophy not only of the muscles themselves, but of the bones to which they are attached. Wherever these special developments are found and whatever the part of the body affected, they are associated with corresponding stimuli which in the individual would cause some degree of the hypertrophy which constitutes the character. I know of no case except colour characters where the special development occurs without some functional activity involving corresponding stimuli. It may be suggested that the peacock's tail has been evolved by the selection by the female of a series of mutations. But why should it be erected ? It may be answered : Because the male wishes to show off his beauty to the hen. But this is sheer anthropomorphism : it is much more reasonable to believe that the bird merely erects his tail under the influence of sexual excitement to invite and excite the hen to satisfy his desires, and the erection of the feathers by contraction of the muscles attached to the follicles necessarily irritates the feather-papillæ. But the chief point in the problem of the evolution of these characters is to explain how these special developments related to external stimuli come to be specially affected by and dependent upon chemical substances given off by the testes. The mutation theory cannot give any reason for this. The genes must be carried in the autosomes, that is, not in the sex-chromosomes, but in the others, which are the same in both sexes, because we know that the characters can develop in both sexes. The internal secretion of the testes (or ovaries) existed already before the sex-limited characters, *e. g.* antlers, arose. The antler was *ex hypothesi* according to the geneticists, not produced by the habit of fighting with the head, but was only selected because it served for fighting. No reason therefore can be suggested from the point of view of genetics, why the antler should be physiologically related to the testes as it is. The hormone theory suggests a possible explanation of this relation.

The most important objection which may be raised against this theory is that it is necessary to assume that the exudations from a given tissue, *e. g.* feather papillæ, in one part of the body are different from those in another part, otherwise stimulation of tail-feathers, for instance, could only produce hypertrophy in following generations of all the feathers of the plumage.

But this is no greater than the difficulty of understanding how a special particle of a chromosome in a gamete affects the development of a special part of the body in the organism developed from that gamete, considering that development consists in the division of all the chromosomes in the fertilised ovum and the cells derived from it. Geneticists are no more able to explain the process of development than Lamarckians are able to give a complete explanation of the heredity of the somatic modifications caused by external stimulation.

It has been objected that only a few special organs give off hormones, and that it is not justifiable to assume that other parts of the body produce such secretions. But this is not strictly correct. The epithelium of the small intestine, which is not a ductless gland, gives off secretion which when conveyed by the blood to the pancreas causes the latter to discharge its own secretion into the intestine. Moreover, the question whether tissues secrete hormones is merely a matter of words. There can be no doubt that every living cell or tissue exudes soluble and diffusible compounds in addition to carbon dioxide and water. Nitrogenous compounds are given off which in the liver are converted into urea, and it is almost certain that the mixture of compounds emitted is different in different tissues, such as muscle, epithelium, and bone.

When we study the ordinary adaptations which are independent of sex, we find that they correspond to differences of habit or environment in different groups of animals which are more or less remote from one another in parentage and descent, except in metamorphosis, where they occur in the same individual and correspond to differences in mode of life in successive phases of the life-history. In either case it can be shown that the different external circumstances involve special stimuli, mechanical, physical, or functional, acting on the animal and capable of producing modifications in organs and tissues different in degree but not in kind from those which constitute the adaptations. This correlation is still more wonderful in the case of sex-limited characters. Here the characters are not only peculiar to animals of separate descent, but to different sexes, different periods of individual life, and in many cases actually to different periods of the year. All these differences of structure or character correspond to periodical changes in the functional activity of the testes or ovaries, and to external stimuli which are involved in habits and actions confined to the periods in which the special characters occur. All these remarkable relations are in harmony with the Lamarckian theory based on the gonadial hormones. Can they be harmonised with the concepts of mutation and selection? The production of individuals

sharply differing in characters from the same parents is very familiar in Mendelian experiments, but in cases of that kind the differences are known to be due to differences in genetic constitution. In the cases of sex-limited characters, there is no genetic difference between the sexes, but only a difference in the sex-hormones. With regard to the development of sex-limited characters at sexual maturity or at the annual breeding-season, I know of no evidence of any such characters arising by mutation. The question, therefore, is why genes which are not themselves sexual in any way should be controlled by sexual hormones. The theory of mutation and selection has hitherto supplied no explanation of this most remarkable fact, and thus sexual dimorphism is actually in itself a sufficient proof of Lamarckism, for the complicated facts which I have mentioned cannot be explained on any other principle yet discovered.

The antlers of stags are one of the cases in which the cycle of development of the sex-limited character follows the sexual cycle. Here an enormous mass of bone grows very rapidly in the spring and summer, persists through autumn and winter, is then shed and annually grows again. When the branched outgrowth is fully developed the skin which covers it dies and is rubbed off, and the bone dies. Then the living cells at the base of the antlers absorb the bone in contact with them, and the antlers fall off bodily, after which new antlers grow out from the old scars. If this was originally a mutation it is curious that it should so closely imitate a pathological process.

On the other hand, it is not necessary to attribute the differences in size, character, and branching of the antlers in different species of deer to different modes of fighting. The antlers having become hereditary were subject, like other hereditary characters, to mutation, which caused the differentiation of species. It is even possible that some differentiation of species had already occurred before the antlers arose.

Lepidosiren, the lung-fish of South America, possesses a very remarkable sex-limited character in the male which consists of long vascular filaments on the pelvic limbs developed only in the breeding-season *.

Darwin, in his thorough and persevering researches on the problem of evolution, devoted a great deal of time and attention to domesticated pigeons, and one of the facts to which he draws attention is that "with the English Carrier and Pouter pigeons the full development of the wattle and the crop occurs rather late in life, and conformably with the rule these characters are transmitted in full perfection to the males alone."

* See Cunningham, J. T., "Vascular Filaments of *Lepidosiren*." Proc. Roy. Soc. B, vol. cv, 1929.

But according to his other conclusion that selection could produce differences between the sexes only by acting on variations already limited in transmission to one sex, the enlarged crop of the Pouter and the enlarged wattle of the Carrier must have arisen from sex-limited variations. There is, however, another feature in these cases which Darwin failed to notice, namely that not only are they the only cases of well-marked sexual dimorphism arising among pigeons under domestication, but they are the only cases in which the structural characters are associated with habits and actions which involve mechanical stimuli to the structures concerned, habits which are practised chiefly by the male sex. All cock pigeons inflate the crop when cooing in courtship, and this habit is inseparable from the enlargement of the crop in the Pouter. In these two breeds it is a common if not universal practice to take the young from the parents and give them to less valuable birds to feed. When this is done the male Pouter is able to strut and pout more frequently than if he were occupied in parental duties. In addition to this he is very carefully trained to pout, and sometimes his crop is even inflated with the owner's breath. Similarly, in the case of the Carrier the young are often put out to nurse, and they are the most quarrelsome and pugnacious pigeons known. Here it is a question not of training them to fight, but of preventing them. The fact remains that as all cock pigeons pout in courtship and fight with other males more or less, the one habit has developed to excess in one breed and the other in the other. In the 'Book of Pigeons' by Robert Fulton, published by A. Cassell & Co., it is stated that Carriers generally fight till quite exhausted, and that their wattle is liable to peculiar risks from fighting. It is scarcely necessary to mention that the beak and eye wattles occur in all pigeons, including the ancestral form *Columba livia*. The effect of fighting, to which I attribute the enlarged wattle of the carrier, is not the actual injury inflicted, but the reaction to the irritation which results in hypertrophy of these epidermic outgrowths. In striking contrast with the characters which differ in the sexes of Pouter and Carrier are the special characters which distinguish other breeds of pigeon from one another and from the original rock-pigeon: the frill in Turbits, the hood in Jacobins, the rose and crest in Trumpeters, the feathering of the feet in Pouters and other breeds. All these are similar in male and female, and are not associated with any special stimuli or functional activity; they are true mutations, not adaptations.

I do not propose to discuss in any detail the sex-limited characters of other phyla of animals than the Vertebrata, although they are numerous and remarkable. But it would require too much space to consider fully the special features presented by these cases.

Descent of the Testes in Mammals.—There is one remarkable character confined to mammals which has an important bearing on the question of adaptation, and which it seems impossible to harmonise with the concepts of selection or mutation, namely the remarkable position of the male reproductive organs in this class. These organs are in the great majority of mammals contained in pouches of the abdominal wall, diverticula of the body-cavity lined with peritoneum, in the lower forms communicating with the general cavity, in man entirely separated from the latter. The organs are developed, as in the lower vertebrates, in the abdomen, attached to the wall of the cavity below the middle part of the excretory system, which is known as the Wolffian body, anterior to the posterior part of that system which becomes in mammals the adult kidneys. The testes reach their final position by a gradual change of position known in human embryology as the descent of the testes, remaining throughout the change connected with the peritoneum by a suspending membrane. The Wolffian body on each side becomes attached to the testis, and forms the epididymis which connects the testis with its efferent duct. The paired pouches containing the testes and covered with skin together form the scrotum, which projects externally and is more or less conspicuous. In some groups of mammals the scrotum is absent and the testes remain in the abdominal cavity as in birds and reptiles.

Now, although mutationists may consider it absurd to attribute such an embryological and evolutionary change of position to the action of gravity and momentum, it is a fact that the presence of the scrotum corresponds precisely to the distribution of the capability and habit of galloping, including under that term all rapid movement by a series of leaps in which the body is completely lifted from the ground *. Thus this mode of locomotion is absent from birds and reptiles in which the testes are abdominal, and present in mammals in which they are contained in scrotal sacs. The cases of mammals in which the testes are abdominal are thus very significant. These exceptions are the aquatic forms Cetacea (whales) and Sirenia (manatee and dugong) and the Phocidæ (true seals), but the scrotum is present in the Otariidæ (sea-lions), in which the hind-feet can be turned forward and which can move on land like quadrupeds. These last, of course, do not gallop, but they have not been so much modified from the primitive condition as to have lost the scrotum. Sloths, which move along branches upside down, have no scrotum, and it is absent also in elephants, which are too heavy to gallop in the proper sense of the word. The scrotum is well developed in

* See Woodland, W., Proc. Zool. Soc. 1903, pt. i.

Marsupials, but absent from the egg-laying mammals *Ornithorhynchus* and *Echidna*.

It has long been known that when the retention of the testes in the abdomen occurs as an abnormality the organs are usually and probably always sterile, and it has been shown that when this condition is produced experimentally sterility results in a very short time. There is also experimental evidence that this sterility is due to the higher temperature of the abdominal cavity as compared with the scrotal. It has been inferred from this that the function of the scrotum is to keep the testes at a lower temperature because that is necessary to the normal development of sperms, and that therefore the evolution of the scrotum can be explained on the principle of selection. Obviously, this conclusion is contradicted and disproved by the fact that the testes are abdominal in birds, in which the temperature is some degrees higher than in mammals, and also in sloths, elephants, and bats, which are mammals. The rational interpretation is that in the majority of mammals in which the testes are normally in scrotal sacs the development of the sperms has in the course of evolution become adapted to the lower temperature of the scrotal cavities, and that for this reason the seminal tubules degenerate when exposed to the higher temperature of the abdomen. The dislocation must be the direct effect of the shocks to which the body is subjected in the galloping or leaping movements, or it must be an unconditioned mutation. But I know of no observed mutation which consists in the movement of an organ, developed originally in a normal position, into such a unique situation as that of the mammalian testes, which pass not merely into the postero-ventral part of the abdominal cavity, but into evaginations of the abdominal wall formed to receive them. As the suggestion of any advantage in the lower temperature is untenable, the idea of selection here is out of the question, especially because the organs in the scrotum must be more exposed to injury than in their original position in the abdomen. It is not suggested that the testes were separated from their original attachment and shaken down to their present position in the mature male. The connexion with the peritoneal membrane persists throughout the change of position, and the effect of the strain must be regarded as the absorption of the connecting membrane anteriorly and its growth posteriorly. This may at first appear impossible, but embryologists know that it actually takes place in the individual development. It may be suggested that, if this theory of the cause of the descent of the testes in mammals were correct, similar effects should have been produced on the ovaries, and also that there is no reason why the position of the testes should have been changed more than that of other abdominal

organs. The answer to these objections, according to the theory, is that the ovaries in mammals are much smaller than the testes, and that the latter have a higher specific gravity and are less firmly attached to the peritoneum than the other organs in the abdominal cavity. In the human subject the testis is more than three times as large and more than four times as heavy as the ovary, comparing the average size and weight *.

General Conclusions.

It may be concluded from the case of the mammalian testes and other cases that the effects of stimuli in evolution are not necessarily adaptive in relation to function or utility, while, on the other hand the essential common characteristic of adaptations is not utility or purpose, but modification of tissues and organs by their reaction to external stimuli. According to this interpretation the antlers of stags from one point of view are weapons, that is organs adapted for fighting, while the scrotum is the result of mechanical strains acting on the testes; but from the Lamarckian point of view both characters are the effects of external stimuli upon the growth of living tissues, both are the reactions of different parts of the living organism to different stimuli. Similarly, the comb and wattles of the genus *Gallus* may be attributed to the irritation of the skin of the head by the wounds and laceration inflicted by the beaks of the cocks in fighting, while the spurs are adaptations for fighting; but both are reactions to the mechanical stimuli involved in the special mode of fighting in sexual combat. Selection and utility, therefore, are not essential to evolution, for some characters are not merely useless but injurious, and many specific and other diagnostic characters are not correlated with differences of environment at all. It is difficult to attribute the comb and wattles of fowls to selection, considering that they are injurious to their possessors by affording a hold to the opponent's beak, and useful in this way only to the opponent. In the flat-fishes the adaptive nature of the distortion which brings the lower eye to the upper surface is obvious, but it seems equally certain that the absence of pigment from the lower side has no utility whatever. Both characters, however, are, on the Lamarckian theory, due to the reaction of different parts of the body to the stimulus of light and the absence of that stimulus. The only sound view of evolution, the only general theory which fits the facts, is, in my opinion, that living animals have always been undergoing changes of two different kinds, namely changes of internal origin which

* See Cunningham, "Exp. on Artificial Cryptorchidism etc." Brit. Journ. Exp. Biol. vol iv. 1927. *Idem*, "Researches on Testis." *Ibid.* vol. vi, 1928.

show no relation to special conditions of environment, and changes of external origin consisting of reactions to external stimuli some of which act directly as in the case of stags' antlers and others indirectly through function, as in the distortion of the ocular region of the head in flat-fishes. The long controversy between Lamarckians and Selectionists is due to the failure to recognize the occurrence of both these kinds of change, to recognize that the differences between varieties and species and other taxonomic groups are not all of the same kind, but of two kinds very different in character and origin, one kind being correlated with external conditions and of external origin, and the other having no relation to external conditions and being of internal origin. There is probably no organism which does not possess characters of both these kinds. Recent research in biology has been chiefly in two distinct directions, forming two branches of the subject known as Genetics and Experimental Biology. The former deals with the heredity of unit characters and the appearance of new unit characters, or mutations in the genes not individually related to special external conditions : the latter deals chiefly with processes in individual development and the influence of internal secretions on these processes. The evidence of genetics suggests that all evolution is mutation ; the discoveries in experimental biology tend, as I have attempted to show, to support the view that all adaptation is the effect of external stimuli. There is no contradiction between the results of these two branches of research : they are dealing with phenomena of two different kinds, both of which together constitute evolution, and it is impossible to explain evolution or the existing characters of animals in terms of either branch of biology exclusively.

OBITUARY NOTICES.

Arthur Bennett (1843–1929) was born on the 19th June, 1843, at Croydon, in which town he was educated and resided throughout his life. On leaving school he went into his father's business, that of a builder and decorator, of which he ultimately became the proprietor. The elder Bennett belonged to the stern parent type, not uncommon in those days, and his son had to begin quite at the bottom of the tree, going through all the drudgery of the trade as an ordinary workman. This rigid early discipline no doubt had its share in moulding his character, and inducing those habits of patient industry and thoroughness which characterized his work.

From an early age he was attracted towards natural history: he first turned his attention to geology, for which, however, circumstances afforded little opportunity; then to entomology, but killing things was repugnant to his kindly nature, and he soon took up the study of plants, which remained the principal pursuit of his leisure time for the rest of his life. He loved plants for themselves, and had nothing in common with the mere collector or with the dry technical biologist, for whom they are so much laboratory material.

His output of articles and notes on botanical matters was very considerable: contributions to the 'Journal of Botany' alone, extending from 1876 to 1929, totalled 199, while, from a list among his papers, it appears that he wrote as many as 183 articles and notes in other publications, including 'Annals of Scottish Nat. Hist.,' 'Scottish Naturalist,' 'Trans. Bot. Soc. Edinb.,' 'Naturalist,' 'Irish Naturalist,' etc., etc. He contributed articles on Naiadaceæ to 'Flora Capensis,' 'Flora of Trop. Africa,' and 'Enumer. of Chinese Plants.' For many years he had been doing good service in collecting and registering new county records supplementary to 'Topographical Botany,' two instalments of which have been published in 'Journ. Bot.,' one in 1905, the other, in conjunction with Messrs. Salmon and Matthews, in 1929, still in progress.

But the scope of his usefulness is not to be reckoned only by what he published; indeed, he probably did almost as much for botany and for the better appreciation of Nature by the help and encouragement he was always so ready to give to others, never sparing time or trouble in the matter.

The tireless activity of the man was astounding. In the intervals of a calling which involved a good deal of strenuous physical exertion he found time, in addition to his own botanical work, to carry on a very extensive correspondence

with botanists both at home and abroad. Moreover, his correspondents were not restricted to botanists: a letter from a child asking him to name a plant would receive the same courteous attention. He made it a rule never to leave a letter unanswered on the day of receipt, and so escaped the curse of procrastination from which so many of us suffer!

It was no doubt largely due to his encouragement that that grand old fenman, Alfred Fryer, was induced to work systematically at the Pondweeds. Owing to Fryer's ill-health and straitened means, the monograph on the British Potamogetons was left unfinished, and Bennett completed it after Fryer's death.

On one occasion, when Bennett undertook the task of distributor for the Botanical Exchange Club, and it came to the making-up of return parcels, he worked on all through the night until it was finished, an example of his immense driving power.

He had a good general knowledge of the British Flowering Plants, but, with the exception of *Carex*, to which he gave special attention, he fought shy of the big critical genera. He knew also a great deal about the flora of the northern parts of Europe, especially the Scandinavian countries, including Iceland and the Faröe Islands. He was much attracted to the water-plants, particularly the Naiadaceæ and Charophyta, and his most important work was in connexion with the genus *Potamogeton*, the study of which he took up on the suggestion of Sir Joseph Hooker, and for which he has been for many years the accepted authority, and has described a number of new species from various parts of the world.

He accumulated a large herbarium: the Foreign Potamogetons, about 4,800 specimens, he bequeathed to the Kew Herbarium: the British the rest, numbering over 20,000, to Mr. C. E. Salmon. His large and valuable collection of Charophyta, British and Foreign, he had many years before generously presented to the writer's late brother and himself. It appears from one of his notes that he distributed 10,000 specimens of *Potamogeton* to herbaria at home and abroad.

He never went far afield, most of his own collecting was in the Eastern and South-Eastern counties. East Norfolk, with its splendid Broads and water-ways, and the Fen-country were his favourite hunting-grounds. In Filby Broad he discovered *Nitellopsis obtusa* (*Chara stelligera* Reichb.), new to Britain; and a few years later he and his daughter added *Naias marina* to our flora, also from the Broads. There is an amusing anecdote in the 'Life and Letters' of his friend A. G. More, telling how Bennett, when he saw More just before they started for Norfolk, actually predicted the finding of the *Naias*!

He was very methodical in dealing with botanical literature, keeping a foolscap sheet for each species, on which he would enter complete references to any information about it that he came across. The freely accorded loan of these sheets was often a great boon to his friends.

Bennett was modest and retiring by nature, and much averse to making himself prominent in botanical gatherings. At the meeting of British botanists to consider the proposals for the 'Cambridge British Flora,' several of us urged him to speak, but he declined, saying that he was not a talker, a matter for regret, as his counsel would have been most valuable in helping to avoid the rocks upon which that ill-fated venture came to grief.

His was a happy genial disposition, and he always gave a hearty welcome to botanical visitors. In figure he was tall and spare, his hair until latterly nearly black, and his eyes particularly bright and piercing, an index of his active mind and the keen interest he took in life.

He was twice married, and had seven daughters by his first wife. His second wife, for thirty years his loving and helpful partner, has survived him, and it is to her, and his great friend Mr. Salmon, that I am indebted for many particulars of his life and work.

A more detailed memoir by Dr. Druce appeared in the 'Journ. Bot.' of Aug. 1929. The delightfully unconventional photograph of Bennett reproduced with that memoir was taken quite impromptu by Mrs. Bennett when he was in the act of tracing the distribution of a plant in the atlas. It will be valued by his friends as a particularly happy presentment of the man as they knew him.

He died on the 2nd May, 1929, close on the age of 86, after a very few days' illness, and in the full possession of his faculties. His death makes a serious gap in the fast diminishing ranks of the older type of botanist—the men who were never *taught* botany—of which he was a much respected and extremely useful representative.

He became a Fellow of the Society on the 3rd March, 1881, but retired in 1905, and had the honour of being elected an Associate in 1910. J. Groves.

Richard Hind Cambage, C.B.E. (obit. 1928), had held a Government appointment—Surveyor of Mines—in New South Wales, and had also served as Under Secretary for Mines. Though not a professional man of science, he had wide scientific interests, and at the time of his death was President of the Australian Association for the Advancement of Science, and was described as one of the most able and active supporters of Australasian science. He was also President of the recently

formed Australian National Research Council, to the objects and work of which he referred in his Presidential Address to the Australian Association at the Hobart meeting in 1928. Mr. Cambage's services to the Commonwealth were recognized by the conferment of the C.B.E.

Mr. Cambage was an active member of the Royal Society of New South Wales, had served as President (1912–13), and was a frequent contributor to its Journal, mainly on subjects dealing with the flora of the Colony. He also contributed a series of papers (1915–24) on the seedlings of *Acacia*, describing their form and development in many species of the genus.

To the 'Proceedings of the Linnean Society of New South Wales' he had contributed various notes on the native flora.

His Presidential Address at Hobart, already mentioned, dealt mainly with the origin and development of portions of the Australian flora, with a summary of the present state of our knowledge. A brief résumé will be found in the 'Journal of Botany' for 1928 (p. 344).

During the visit of the British Association to Australia in 1914, Mr. Cambage acted as one of the hosts at Sydney, and co-operated with the late Mr. Maiden in an account of the botany of certain areas of the colony in the B. A. 'Handbook for New South Wales.' The writer remembers him specially as a pleasant companion and helpful guide during a week-end botanical excursion in the Blue Mountain district.

Mr. Cambage was elected F.L.S. in 1904. His death, at the age of 69, occurred suddenly on November 28, 1928.

A. B. Rendle.

William Richard Carles (1848–1929), whose death was recently announced, was born on June 1st, 1848, educated at Marlborough College, and entered the Consular Service in China in 1867. According to Bretschneider, 'History of European Botanical Discoveries in China,' p. 755, he first collected plants near Chefoo in company with the late F. B. Forbes in Sept. 1880, and again in the following year in north-western Chekiang. His most important collections of herbarium specimens, however, were from Corea, where he was stationed from 1883 to 1885. The results of three journeys in that country appeared in 'Proc. R. Geogr. Soc.' vol. viii (1886), pp. 289–312. In later years he botanised in Kiangsu and Fokien. Several new species were described by Hemsley from Carles's collections, the most noteworthy being *Viburnum Carlesii* ('Bot. Mag.' t. 8114), a Corean species which has since come into cultivation in this country and "is undoubtedly one of the most delightful of Viburnums not only

for the beauty of the flowers, but for a fragrance unrivalled for sweetness in the genus" (Bean, 'Trees and Shrubs hardy in the British Isles,' ed. 3, ii. p. 644).

Carles rose to be Consul-General at Tientsin and Peking in 1900 and resigned in the following year, receiving the C.M.G. on retirement. He was elected a Fellow of the Society in 1898. A set of his plants from Corea, Kiangsu, and Fokien is in the Kew Herbarium. T. A. Sprague.

Charles Chilton (1860–1929) was born at Leominster, Hereford, England, on Sept. 27th, 1860, but went out to New Zealand with his parents while he was yet a young boy. Owing to hip trouble his left leg was amputated at an early age, but even with this great handicap he soon acquired the power of getting about with great freedom and activity. Those who have wandered with him in rocky and mountainous country were astonished at the way in which he could climb up and down with rapidity. His parents settled at East Eyreton, in the Canterbury district. It was originally intended that he should become a farmer, an occupation which his younger brothers followed successfully. But for Charles a professioual training was decided on, and he was sent to West Christchurch School, where later he became a junior member of the teaching staff. He attributed much of the success which he afterwards achieved as a teacher to the training he received at a primary school. In commenting in after years on the professors he studied under, he often expressed the opinion that all teachers, whether in secondary schools or in universities, should receive part of their training in a primary school.

Entering Canterbury College in 1875 as an unmatriculated student, he studied for three years, passed his matriculation examination, and at the end of 1878 gained a Junior University Scholarship. Two years later he completed his B.A. degree with an exhibition in natural science, and senior scholarship in English, physics, and natural science. In 1881 he gained his M.A. degree with 1st class honours in zoology. At this period Captain F. W. Hutton was Professor of Biology in Canterbury College, and it was his association with this inspiring teacher and naturalist which led Chilton to concentrate his chief attention on biological study. On the advice of his professor he resolved to specialize on the study of the Crustacea, a group which up to that time had received little attention in New Zealand, but which has since, under his hands, become very well known. He also got into touch with the writer of the present sketch, who was a member of the staff of the Otago High Schools, and who had already begun to study Crustacea (also following Hutton's inspiration), and the two collaborated for years in research on this interesting group. The friendship

thus inaugurated was strengthened as the years passed, and only closed by Chilton's death.

In 1886 he was appointed to a position in the Training College, Dunedin, and continued his studies at Otago University, taking the degree of B.Sc. in the following year, and being the first student to gain this honour in the New Zealand University. In 1893 he gained his doctorship in science, being again the first to gain this N.Z. degree. He was elected F.L.S. in 1892.

While at the Training College he met Miss Elizabeth Jack, then a student in training there, and they were married in 1888, when he was appointed Rector of the Port Chalmers District High School. In this position he was able to devote most of his spare time to the study of the marine zoology of Otago Harbour. From the point of view of the naturalist these were fruitful years, but there was no outlook for a man of his tastes and ambitions in the primary school branch of the teaching profession. It was the subject of much cogitation between himself and his devoted wife that ultimately led to his decision to throw up his position and devote himself to medicine as a career offering a wider field. It was a very courageous step to take, for it meant at least four years of work without earning, and a sacrifice of much previous effort and progress. But the decision was taken, and in 1895 he entered on his medical studies in the University of Edinburgh. This meant four years of strenuous work, but he was awarded prizes in botany, surgery and physiology, and in 1898 gained his degrees of M.B., C.M. with honours, and also won the Aitken Carlyle scholarship. He had all along resolved to specialize in his medical work, and he devoted himself especially to the study of diseases of the eye, ear, and throat. In the following year he was house surgeon in the ophthalmic ward of the Royal Infirmary, Edinburgh, and in 1900 studied diseases of the eye at Heidelberg, Vienna, and London.

On returning to New Zealand, at the close of that year, he wisely resolved to select his own city of Christchurch as his field of operations, and commenced practise as an ophthalmic surgeon early in 1901. At this time Dr. Dendy was Professor of Biology in Canterbury College, and having got a year's leave of absence, he got the Board of Governors to offer Dr. Chilton the position of *locum tenens*. Before the opening of the next session Dr. Dendy had accepted the position of Professor of Biology in King's College, and the Board appointed Dr. Chilton to the office thus vacated. He occupied the chair of Biology and Palæontology till 1910, and from thence till his resignation in 1928 the chair of Biology alone.

In 1915 he and Mrs. Chilton lost their only son (and child), Frank, a young man of great promise, who was killed

at the fatal landing at Cape Helles, on the Gallipoli peninsula. The bereaved parents met their loss with heroic fortitude.

In 1921 Dr. Chilton was appointed Rector of Canterbury College, being the first to hold that position in any New Zealand or Australian university college. He resigned it in 1928. In recognition of his 26 years' service as Professor and Rector, Dr. Chilton was appointed as Professor Emeritus of Canterbury College at a meeting of the Board of Governors held on April 1929.

During his professorship the Canterbury Mountain Biological Station at Cass was established, where practical work in the field yielded profit and pleasure alike to teachers and students. Throughout his life he had devoted much attention to the encouragement of education. He was a member for several years of the committee of the W. Christchurch District High School, a member of the Canterbury Education Board, and a member of the Board of Governors of Canterbury Agricultural College, Lincoln, and chairman of that body in 1927. Many of those who were long associated with Dr. Chilton have spoken with appreciation of his work as an educationist. One reference may be quoted here :—Dr. Hilgendorf said of him : " He had never known a man who turned with such understanding and with such effect to the young ; his influence in this direction was very great, and no student or worker who had even the slightest connection with him but had felt that influence. Many had been guided by his wisdom and many had been inspired by his encouragement to carry on and complete their work."

Dr. Chilton's scientific researches were chiefly devoted to the Crustacea, and even in this group he wisely resolved to confine his work to the larger forms—specializing particularly in the Amphipoda and Isopoda. A few workers have studied the whole field of this interesting class of animals, notably the late Dr. G. O. Sars of Christiana (Oslo), Norway. But most have found it the wisest plan to specialize. As already indicated, much of Dr. Chilton's inspiration was due to the teaching and example of the late Professor F. W. Hutton, who was not only an enthusiastic naturalist, but a most generous and unselfish worker. The student in such a specialized line of research as the Crustacea is working a lone furrow so far as local co-operation and assistance is concerned. Dr. Chilton's earlier work in this field was largely carried on in collaboration with the writer of this memoir. But after his return to New Zealand he was in touch with workers in other parts of the world, and thus broadened his researches and experience until he became a recognized and trustworthy authority in his special groups. His first scientific paper, entitled " Additions

to the New Zealand Crustacea," was read before the Canterbury Philosophical Institute on 13th Oct., 1881, and was followed by one on 3rd Nov., " On some Subterranean Crustacea." The discovery and description of these well-shrimps from Eyreton fully opened his eyes to the fascinating research on which he had entered. In 1881 he became a member of the Canterbury Philosophical Institute, and these first papers, published in vol. xiv of the ' Transactions of the N.Z. Institute,' were the forerunners of a series which lasted till 5th Nov., 1924, when his last paper (printed in 1926 in vol. lvi) was read before the same society. Altogether he contributed fifty-one papers to the ' Transactions ' of the Institute.

His first foreign paper, " On a Marine Species of *Philougria*," was printed in 1884 in the ' Proceedings of the Linnean Society of New South Wales,' vol. ix, and this was followed by a great list contributed to some twenty different journals and societies. Among the most important of these were papers on " The Subterranean Crustacea of New Zealand," in the ' Transactions of the Linnean Society,' vol. lxv ; " The Amphipoda of the Scottish National Antarctic Expedition," printed in the ' Transactions of the Royal Society of Edinburgh,' vol. xlviii ; and on " The Fauna of Chilka Lake," in ' Memoirs of the Indian Museum.' His contributions to zoological knowledge were published in New Zealand, Australia, Great Britain, India, the Malay States, Holland, Germany, Sweden, and the Philippine Islands.

His association with learned societies commenced in 1881, when he joined the Canterbury Philosophical Institute. He was elected President in 1903, 1904, and 1913. He also represented that branch of the New Zealand Institute on the Board of Governors, first as representative of the Canterbury branch and for many years as a Government nominee, and as President in 1913–14. In 1917 he was awarded the Hector Memorial Medal for " researches in zoology." Two years later he was gazetted one of the original Fellows of the New Zealand Institute ; and in 1926 was awarded the Hutton Memorial Medal " for his continuous researches on the Amphipodous Crustacea of the Southern Hemisphere." He was also awardedt he Mueller Medal, an Australian honour held in New Zealand by Dr. Chilton only. In 1892 he acted, along with the present writer, as a joint Secretary of the Biological Section of the Australasian Association for the Advancement of Science, which met in Christchurch that year, and he remained an active member of that body. For some years he was convener of a sub-committee for the hydrographic investigation of New Zealand seas.

It was a matter of regret both to Dr. Chilton and to his friends that he had never brought together the results of his

scientific labours, as far at least as certain branches of the Crustacea were concerned, into one monograph. This was certainly in his mind when he retired from the dual position of Rector and Professor in Canterbury College. He had made all arrangements for carrying on his researches at the Cawthron Institute, Nelson, but the strain of so many years of arduous and unceasing work told so severely on his health that he had to abandon the idea and rest for over a year. He had, however, recovered his health later, and was once more fully into the swing of his favourite research when he succumbed to a sudden attack of pneumonia on 25th October, 1929.

If Dr. Chilton had not achieved the success he did in scientific work he would have still earned the gratitude of the people of the Dominion for his contributions to education, and—as far as Christchurch and Canterbury were concerned—to social work. In every sense of the word he was a good citizen, labouring unceasingly for the public good. He took a keen and live interest in several public matters, and "his fellow-workers can best tell of the scrupulous accuracy and thoroughness of his work, the unflagging industry that made it so, and the devotion to scientific truth that inspired this industry. No other life in the Dominion has ever been more generously given to the patient toil of learning and teaching, and yet has been so little in danger of becoming absorbed by them, to the exclusion of thought on the ends of learning and life."

Dr. Chilton's private life was sanctified by the unselfish comradeship, courage, and constancy of his life-partner. This was his greatest inspiration, not only in times of deepest sorrow, such as came to so many parents during war-time, but throughout all his public and private work. How great that inspiration was only those most intimate friends knew, but it deepens the sympathy which is felt for one who has faced the difficulties of life with joyful ardour, and its sorrows with the utmost bravery. G. M. Thomson.

Charles C. Coltman-Rogers (1854–1929), of Stanage Park, Radnorshire, was born in 1854, and was educated at Eton and Brasenose College, Oxford.

He was Chairman of the Botanical and Zoological Committee, and also of the Forestry Committee, of the Royal Agricultural Society, Chairman of Council of the Royal Welsh Agricultural Committee, and also Chairman of the Forestry Committee of the Shropshire and West Midland Agricultural Society.

From 1896 until his death he was Chairman of the Radnorshire County Council. He served as Lord Lieutenant of that county since 1922. He was M.P. for Radnor Boroughs 1884–5.

Coltman-Rogers was specially interested in the breeding of Welsh ponies, and in coniferous trees. He planted his own estate with a large variety of shrubs and trees, especially Coniferæ. He was the author of ' Characteristics of Conifers ' (John Murray).

He was elected a Fellow in 1921 and died on May 20th, 1929.

F. Druce.

Walter Gill died at his home, Malvern, South Australia, on July 17th, 1929, in his 78th year. He was the son of the Rev. W. Gill, Independent Minister of Parkstone, Dorset. He was educated at a school kept by his father, and was wont to attribute his interest in botany to the teaching of his mother during his early rambles in the English countryside. Gill was always an active collector, and used to say that, when a young man serving in a bank in England, he thought nothing of walking ten miles before work to collect some desired specimen. In December 1876 he went to South Australia to gain pastoral experience with an uncle. Eight years later he entered the Government service as an inspector of credit-lands. His duties involved travelling many thousands of miles on horseback or by buggy, and during these tours he collected largely, sending his specimens either to E. J. Brown, then Conservator of Forests in South Australia, or to Baron Sir Ferdinand von Mueller in Melbourne. With the latter there grew up a botanical friendship only terminated with the Baron's death. In 1886 Gill became Chief Forester at Wirrabara, South Australia, and four years later succeeded E. J. Brown as Conservator of Forests in the colony. This office he held for 33 years. It is only to be expected that the forest policy of South Australia owes much to Gill's influence. He early became impressed by the potential importance of the Remarkable Pine (*Pinus radiata* syn. *insignis*), by which latter name he always referred to it, following the practice of " the Baron." During his long period of office he lived to see the first plantations that he had made felled and sawn, often with surprisingly profitable results. Thus from four plantations at Wirrabara, covering in the aggregate 73 acres, a gross column of 5,313,437 super feet was obtained (counting all logs to 3 inches diameter). D. E. Hutchins, late Conservator of Forests in South Africa, said of these plantations, after an extensive tour of Australian forests in 1914, that they were " the finest growth of any forest plantation on the Australian Continent."

Gill's official duties kept him much in the field. Apart from official reports he published little. He was, however, a skilled photographer, and many valuable pictures of South Australian forest trees appear in the long series of Annual Reports issued from his pen. His field collections and notes were of great

value to the late J. H. Maiden and R. T. Baker in their respective works on the genus *Eucalyptus*. Maiden named species of both *Eucalyptus* and *Acacia* after Gill.

Walter Gill was a useful member of the Board of Trustees of the National Park of South Australia from its formation until the time of his death. He was elected a Fellow of the Linnean Society of London in 1890 on the proposition of Baron von Mueller. He is survived by a daughter and three sons; his widow predeceased him in 1916. T. G. B. Osborn.

George Henderson (1836–1929) was the eldest son of the Rev. Dr. George Henderson of Cullen, and was born there on the 29th November, 1836. He was educated at Cullen School and Aberdeen University. After taking his M.D. degree he was appointed to the medical service of the Honourable East India Company shortly before the Company was superseded by the Crown in the administration of India after the Mutiny. Henderson did not go out to the East, however, until 1859, the intervening time being spent in Paris, where he studied surgery under the famous Nelaton.

After arrival in India he served for some time as a regimental medical officer, and later became Superintendent of the Central Jail, Lahore. There he introduced many reforms in administration and in the treatment and rational employment of prisoners.

In 1870, while still at Lahore, Henderson was selected as medical officer and scientific observer to the Mission sent by the Government of India to Yarkand. An interesting account by Henderson and A. O. Hume of the journey and of its scientific results was published in one volume in 1873, under the title of 'Lahore to Yarkand,' illustrated with coloured plates of birds and plants and with photographs of the regions traversed.

After the Yarkand journey Henderson came home on leave, and while at home was elected a Fellow of our Society on 15th February, 1872, so that he was a very senior as well as aged member at the time of his death. His leave was cut short by his being recalled to India to officiate as Superintendent of the Royal Botanic Garden, Calcutta, during the absence of Dr. (afterwards Sir George) King.

Thereafter Henderson reverted to the ordinary civil-surgeon side of the Indian Medical Service, in which he continued until his retirement as Lieut.-Colonel in 1891. During this latter period of his service he still kept up his interest in natural science and in horticulture, and wherever he was stationed he left his mark in the introduction of trees, the planting of avenues, the laying out and improvement of public gardens, and other such beneficent activities.

He spent many years of his retirement abroad, but finally settled in Inverness, where he died on the 23rd June, 1929, in his ninety-third year.

This brief account is based on a longer sketch of Col. Henderson's life published in the 'Inverness Courier' of the 25th June, 1929, to which the writer desires to express his indebtedness.

A. T. Gage.

Augustine Henry (1857–1930), whose death took place in Dublin on March 23rd, was recognized as one of our leading authorities on the trees of the temperate regions, and his death will be greatly regretted by his many arboricultural friends. As is generally known, a good part of his earlier life was devoted to botanical exploration in Western and South-Western China, which earned for him the name of "Chinese" Henry. Born on July 2nd, 1857, Henry was educated for the medical profession. He graduated M.A. of Queen's University of Ireland and was L.R.C.P. Edinburgh. In 1880 he became attached to the medical staff of the Chinese Imperial Maritime Customs at Shanghai. A year or so later he was appointed medical officer to the Customs Station at Ichang, a port on the Yangtze River in the province of Hupeh, 1000 miles from the sea. About 1885 he started to explore the rich and at that period practically unknown flora of the wonderful mountain gorges by which the great river finds its exit to the plains a few miles above the town, and began the famous plant collections which were to make him famous in the botanical world. The first of these collections arrived at Kew in 1886. It was found to contain a large number of new genera and species, and its value and interest were quickly realized. In 1888 Henry, having obtained six months' leave, made two further plant-hunting expeditions in the mountains to the south-west of Ichang and in the highlands to the north of the Yangtze, going over the border into Szechuan. These trips yielded a rich harvest of novelties which, when worked out at Kew and described by Hemsley in the 'Index Flora Sinensis', were found to include no less than 20 new genera and 500 new species. Many of these novelties were decorative trees and shrubs which have since been rediscovered and introduced into cultivation by later collectors, and have proved of great value as garden plants. After a year at home, Henry returned to the Chinese Customs at Shanghai in 1891, and the next year he was transferred to Formosa. There he stayed until 1895, making further plant-hunting expeditions and collecting about 2000 specimens, mainly in the Tahow district. These are enumerated in the 'Trans. Asiatic Society of Japan,' xxiv, Suppl. 1896. In 1896 Henry spent four years in Southern Yunnan, where he discovered many rare and interesting

species, including the Wild Tea plant, only previously known from one locality outside Assam. "A Budget from Yunnan" ('Kew Bull.' 1897–99) contains his account of these explorations in the virgin forests there. Since 1900, when he finally left China, Henry had devoted his life to the study of arboriculture. For this purpose he first spent two years at the Forestry School at Nancy, and later travelled extensively in Europe and North America, with the object of studying trees in their native countries and gaining first-hand knowledge of them.

About this time Henry collaborated with Elwes in the production of their monumental work 'The Trees of Great Britain and Ireland.' The collection of materials for this work and the research in connection with it involved an immense amount of labour and some ten years of the authors' time. The first of the seven volumes was published in 1906 and the last in 1913. Both men were peculiarly fitted for the task they had set themselves, as they had studied on the spot, both at home and abroad, most of the trees they described, and the result was the most practical and comprehensive work of its kind which has appeared since Loudon's time. It will no doubt remain the standard book on arboriculture for a long time to come.

While working on the book with Elwes, Henry was in 1907 appointed Reader in Forestry at Cambridge University, and subsequently became Professor of Forestry in the College of Science at Dublin, from which post he resigned in 1926.

During the latter part of his career Henry became interested in the breeding of trees on Mendelian lines and the production of vigorous trees by hydridization, and published accounts of his experiments in this Society's Journal (xxxix, p. 27, 1910) and in the 'Journal of the Department of Agriculture.' He published in 1919 'Trees and Hygiene,' a work emphasizing the importance of the afforestation of our water catchment areas. He was also a large contributor to the Forestry, Horticultural, and other scientific Journals.

Henry had been a Fellow of this Society since 1888. He was also a member of the Royal Irish Academy, by which many of his papers were published. In 1902 the Royal Horticultural Society awarded him the Veitch Memorial Medal and in 1906 the Victoria Medal of Honour. In 1923 he was awarded the Silver Medal of the Société National d'Acclimatation de France.

Henry had a vigorous and attractive personality, and possessed a great store of out-of-the-way information on a variety of subjects. My first acquaintance with him was at Kew in the spring of 1907, while he was working on one of the earlier volumes of the 'Trees of Great Britain.' I became his

assistant, and was put in charge of the herbarium he and Elwes had accumulated during their travels, and which at that time was housed in Cambridge Cottage. I remember being very much impressed by his enthusiasm and energy. During the summer months we were frequently at work at 6 A.M. collecting specimens in Kew Gardens for study. Henry spent a great deal of time constructing keys for the identification of trees based entirely on leaf and shoot characters, which under constant test have proved as near fool-proof as it is possible to make them. His work on critical genera like *Populus*, *Ulmus*, and *Betula* was very thorough, and his conclusions, though often arrived at in typical Irish style, were generally sound. Some of us thought, however, that his theories about the hybrid origin of trees were sometimes misapplied, being often based on insufficient evidence, but he spared no pains to arrive at the truth. I esteem it a privilege to have worked with him, and his death is a personal loss to me. A. BRUCE JACKSON.

Sir EDWIN RAY LANKESTER was born at 22 Old Burlington Street, London, on May 15th, 1847, and died unmarried on Aug. 15th, 1929. He was a conspicuous example of hereditary genius, both his parents having been well-known workers in science, whose love for Nature is exemplified by the fact that three of their sons were named respectively Ray, Forbes, and Owen. The mother was a Miss Pope, sister of Samuel Pope, Q.C., *facile princeps* of the Parliamentary Bar, and she was the author of several well-known books on British Ferns and Flowering Plants. The father, Edwin Lankester, M.D., F.R.S., was born in 1814 at Melton, Suffolk, and was educated at Woodbridge School, subsequently studying medicine at University College, London, 1834–1837. He produced various works on Zoology and Botany, and he was the first Editor of the ' Quarterly Journal of Microscopical Science.' The name he chose for his son, the subject of this Notice, was obviously connected with the facts that in the year before Ray's birth the Ray Society, of which he was the Secretary, had published his ' Memorials of John Ray,' and that he was engaged in the preparation of a second volume concerning this eminent Naturalist, which appeared in 1848. In 1862 Dr. Lankester was elected, at hustings at the Langham Hotel, Coroner for Central Middlesex, and he was the first medical Coroner to be appointed in this country. He died in 1874, and the following extract from an Obituary Notice (' Quart. J. Micr. Sci.' xv, 1875, p. 59) is significant as showing how much the son owed to the father :—" He was a born naturalist, and much of his literary energy was spent in endeavouring to lead amateur users of the microscope to a higher conception of the dignity of their favourite pursuit. He early imbued his

eldest son, in whose intellectual development he was most deeply interested, with his own love for natural objects. Whatever he has achieved may be fairly set down as due to the teaching and example of Dr. Edwin Lankester."

Ray Lankester was the second child and eldest son of this distinguished couple. Three of the eleven children died in early youth and four still survive, namely, Edward Forbes Lankester, K.C., Police Magistrate of West London from 1921, now retired and living abroad; Owen Lankester, M.D., a medical practitioner in London for more than forty years, who for several years had been demonstrator to his brother at University College; Mrs. Vatcher; and another (unmarried) sister, a deaconess working in Cork.

Not only did Ray grow up in a home environment which fostered his love of Nature, but he was fortunate in having such intimate acquaintances, in his early life, as Richard Owen and Thomas Henry Huxley. He always acknowledged his indebtedness to Miss Hodgkin, his governess, who took him to the British Museum, and in other ways encouraged his interest in Natural History. His education was continued at St. Paul's School, where he took many classical prizes. From 1864 to 1866 he was an Undergraduate at Downing College, Cambridge, thence migrating to Christ Church, Oxford, where he spent the next two years, 1866 to 1868; graduating with first-class honours in Natural Science and gaining the Burdett-Coutts Scholarship in Geology. In 1870 he became Radcliffe Travelling Fellow, and in the winter of 1871–2 he was engaged in zoological studies at Naples. Anton Dohrn, with whom he worked in close friendship, was at that time negotiating with the Naples Municipality for the site on which the "Stazione Zoologica" was shortly afterwards erected ('Secrets of Earth and Sea,' 1920, p. 65). Lankester gave a vivid account of an impressive eruption of Vesuvius, on Nov. 1st, 1871, and he ascended the mountain on that night with Dohrn. He was also fortunate in seeing the much greater eruption in April 1872.

Lankester's observations on Invertebrates ('Ann. Mag. Nat. Hist.' 4, xi, 1873, p. 81), made during this visit, covered a wide range, and opened lines of study which he subsequently followed in greater detail. Among these may be specially mentioned his use of the spectroscope, by means of which he ascertained the presence of hæmoglobin in the nerve-cord of *Aphrodite*, in the blood-corpuscles of *Solen legumen* and of *Phoronis*, and in the perivisceral corpuscles of *Glycera* and of *Capitella*, and his studies on the development of Molluscs. His success as an investigator was early recognized by his election to a Fellowship and Lectureship at Exeter College in 1872. In 1874 he gave up his work at Oxford to become

Professor of Zoology and Comparative Anatomy at University College, London, a post which he held till 1890. In 1875 he was elected into the Royal Society, at the early age of 28; he served on its Council on four separate occasions, and he was Vice-President in 1882–3 and in 1895–6. He was awarded a Royal Medal in 1885 and the Copley Medal of the Society in 1913. He joined the Linnean Society in 1876 and remained a Fellow for 53 years, serving on the Council in 1881–2 and receiving a Darwin-Wallace Medal in 1908 and the Linnean Medal in 1920.

On July 1st, 1908, the Linnean Society had held a Special Meeting to celebrate the Fiftieth Anniversary of the joint communication made to the Society by Charles Darwin and Alfred Russel Wallace "On the Tendency of Species to form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection." The high estimation in which Lankester was held by the Society is shown by the fact that the other Darwin-Wallace Medallists were Wallace himself (who was present), Sir Joseph Hooker, Ernest Haeckel, August Weismann, Eduard Strasburger, and Francis Galton. A full account of this interesting episode is given in a special publication of the Society which contains a reprint of the joint communication of Darwin and Wallace and portraits of the seven Medallists.

In 1882 Lankester was appointed to the Regius Professorship of Natural History in the University of Edinburgh, but he resigned within a fortnight, as he was not satisfied with the conditions under which he could carry out researches there; and he resumed his duties at University College. From 1891 to 1898 he was Linacre Professor of Comparative Anatomy at Oxford, and he was Director of the Natural History Departments of the British Museum and Keeper of Zoology from 1898 to 1907. While responsible for the Oxford University Museum he had taken great interest in the preparation of exhibits to illustrate the facts of Comparative Anatomy, and he made use of the larger opportunities afforded by his position at South Kensington to introduce new exhibits which should be of greater educational value than the purely systematic arrangement in which most of the specimens had hitherto been shown. The most notable of these was the collection he brought together to illustrate Domesticated Animals, in the North Hall of the Museum ('Science from an Easy Chair,' 1910, p. 82). This interested him specially as a contribution to the study of Evolution, in order to allow a comparison between the breeds now existing and "the later developments which the continual selection of winner's blood in breeding must unconsciously produce." The Fish and Reptile Galleries were completely re-arranged under his supervision. The earlier series had consisted mainly of an unduly

large number of stuffed specimens, of no great interest to the general public, but they were now replaced by a smaller number of specimens or casts painted to resemble the living animals in their natural colours, and by others chosen to illustrate the distinguishing characters of the more important subdivisions, recent and fossil, of these two large groups. Three imposing Dinosaur skeletons (casts) were placed in the Reptile Gallery—Mr. Andrew Carnegie's gigantic *Diplodocus*, *Triceratops*, and *Iguanodon*. Many of the large Mammals were improved by the addition of groundwork resembling the type of country in which they respectively live. A special exhibit of British Vertebrates was arranged, some of the cases with appropriate backgrounds and foliage. Specially interesting exhibits, often including enlarged and accurate models, were placed in the Central Hall to illustrate such subjects as the transmission of Malaria by Mosquitoes and of Sleeping Sickness by Trypanosomes. By various re-arrangements much needed additional space was liberated for the provision of studies required by members of the staff. Funds were collected for important expeditions, including an exploration of the fauna of Lake Tanganyika and the remarkably successful Fayum Expedition, which resulted in the discovery, by Dr. C. W. Andrews, of the presumed ancestral history of the Elephants. Special attention was given by Lankester to improved methods of labelling and to the publication of Guide Books and of a History of the Collections in the four Departments. It had formerly been supposed that the Museum was precluded by the terms of an Act of Parliament from sending away specimens. Lankester was successful in obtaining a ruling from a great legal authority that the words of the Act had not the restrictive sense which had been attributed to them, and the Trustees thereupon took action by which it became possible to send collections to specialists, at home and abroad, for determination. This procedure has been greatly to the advantage of the Museum. By insisting on the necessity of a wide training in the principles of science as a qualification for an appointment in the Museum, he substantially improved the general efficiency of the scientific staff. His numerous services to science were rewarded, in the year of his retirement, by the bestowal on him of the honour of K.C.B. He had been President of the British Association in the previous year (1906), and he had been Fullerian Professor of Physiology and Comparative Anatomy in the Royal Institution from 1898 to 1900. He received Honorary Degrees, at various times, from Oxford, St. Andrews, and Leeds, and he was Honorary Fellow of Exeter College, and Honorary Student of Christ Church, Oxford.

Lankester's preeminent position in Science was also recognized by numerous learned Societies abroad. He was

Member of the Institute of France (Academy of Sciences); Corresponding Member of the Imperial Academy of Sciences, Petrograd; Foreign Member of the Royal Bohemian Society of Sciences, of the New York Academy of Sciences, of the Academy of the Lincei of Rome, of the Royal Belgian Academy, of the Royal Society of Göttingen, of the American National Academy of Sciences, of the American Philosophical Society, of the Biological Society of Paris, of the Academy of Sciences of Philadelphia, and of other Societies.

The Royal Society Catalogue of Scientific Papers, which does not go beyond 1900, contains a list of nearly 180 papers published in journals by Lankester; and to this number must be added other works which appeared separately. It is noteworthy that the first four are dated either 1862 or 1863, when he was only 15 or 16 years old; and that the next five belong to 1864, the year in which he entered Downing College. A large proportion of the early papers are Geological or Palæontological, and were mainly concerned with Palaeozoic fishes and with the Crag of East Anglia and its Mammalian fossils. This phase culminated in the publication (1868–1870) of the 'Monograph of the Fishes of the Old Red Sandstone of Britain—Part I, The Cephalaspidæ' (Palæontological Society). After the completion of this work, his devotion to the morphological side of Zoology became predominant, although in later years his interest in Geology was revived, as shown by his paper "On the Discovery of a Novel Type of Flint Implements below the Base of the Red Crag of Suffolk, proving the Existence of Skilled Workers in Flint in the Pliocene Age" ('Phil. Trans.' B, ccii, 1912, p. 283). He consistently upheld this interpretation of "rostro-carinate" flints, and he took a special interest in the recent work of Mr. J. Reid Moir on these lines.

It was as a morphologist that Lankester specially made his mark, and he was beginning to be recognized as a master in this subject while still a young man. He combined a remarkably extensive knowledge of comparative anatomy with a mind quick to recognize the significant facts, and with the power to express his conclusions clearly, forcefully, and convincingly.

Lankester's early work is a striking example of what can be done by an able observer who makes use of the common objects around him. Up to 1869, when he was only 22, he had contributed to scientific journals no less than 42 papers, 18 of which were Geological or Palæontological. The remainder include detailed accounts of the anatomy of the Earthworm (till then very imperfectly known); observations on the mud-worms (*Tubifex*) of the Thames, a subject which was more fully dealt with in 1871 in a paper containing a

description of the remarkable spermatophores of these and other Oligochæta ; the sexual form of another Oligochæte, *Chætogaster*, in which the forms usually found are asexual and multiply by fission ; the boring of calcareous rocks by Polychæte worms ; the anatomy of the Limpet ; and spectroscopic examinations of the blood of Invertebrates.

The first 16 volumes of the ' Quarterly Journal of Microscopical Science ' had been published in 1853–1868, with Dr. Edwin Lankester as the principal Editor ; but for the next three years Ray was associated with his father in this capacity. He became the principal Editor in 1877, and remained thus until 1920, after which his name appeared on the title-page as Honorary Editor. For 52 years he edited this Journal, which has taken a high place in the literature of Zoology ; and this must be counted as one of his notable services to science.

In 1870 Lankester published a small volume, ' Comparative Longevity,' and an important paper (' Ann. Mag. Nat. Hist.' 4, vi, p. 34) on the resemblances between the organs of animals. In the latter, after remarking that Owen had been the first to give a clear definition of " homology," he introduced the terms " homogeny " and " homoplasy " for two different kinds of homology. Structures which have a single representative in a common ancestor are " homogenous." Identical or nearly similar forces, or environments, acting on two or more parts of an organism which are nearly alike, or on the structures of two different organisms, produce " homoplastic " resemblances ; and as examples of this kind of homology he cited the similarity of the fore and hind limbs of Vertebrates and other cases of serial homology, the jointing of the antennæ in Insects and Crustaceans, and the resemblances between the fins of Cetacea and Fishes.

During the decade 1870–1879 Lankester was specially concerned with the embryonic development of animals. He summarized the known facts of embryology in two masterly essays, " On the Primitive Cell-layers of the Embryo as the Basis of Genealogical Classification of Animals " (' Ann. Mag. Nat. Hist.' 4, xi, 1873, p. 321) and " Notes on the Embryology and Classification of the Animal Kingdom " (' Quart. J. Micr. Sci.' xvii, 1877, p. 399). He had himself made important contributions to the subject by his papers on the development of Mollusca, the most substantial of which was his memoir communicated to the Royal Society (' Phil. Trans.' clxv, 1876, p. 1). Many of the terms now in universal use by embryologists were introduced by Lankester, about this time, in the ' Quarterly Journal of Microscopical Science,' as, for instance, Trochosphere, velum, Veliger, shell-gland (xiv, 1874), blastopore (xv, 1875), archenteron, proctodæum, stomodæum (xvi, 1876), and nephridium (xvii, 1877). It is hardly possible

to speak too highly of the value to students of these clear expositions, not only of his own investigations and opinions, but also of the notable work of Haeckel, one of whose works appeared in 1876, in an English translation which had been revised by Lankester, under the title of 'The History of Creation.' A careful study of the two essays mentioned above can still be confidently recommended to any student of Embryology who is not already acquainted with them.

In 1880 (see 'Science from an Easy Chair,' 1910, p. 58) an event occurred which specially aroused Lankester's enthusiasm —the first discovery of Jellyfish in fresh water, and in London. I was at that time working as one of his students at University College, and I have a vivid recollection of his appearance in the laboratory with a jar containing numbers of these organisms (*Craspedacusta* or *Limnocodium*), which had just been found in the *Victoria regia* tank of the Royal Botanic Society in Regent's Park, and of the intense interest he took in this remarkable event. It is characteristic of him that he delighted in giving his pupils the opportunity of sharing in this thrilling experience. The first results of his investigation of the new Jellyfish were published principally in his own journal (xx, 1880). His remarkable discovery that all the specimens were males is still an enigma which has not been completely elucidated, although it appears probable that the medusæ had been budded off from a unisexual Hydroid stock. *Limnocodium* reappeared in the same tank for several years afterwards, and then not again for about 37 years. It has more recently been found in North and Central America, in Germany, and even in the Exeter Ship Canal; but, with one exception, later observers have had the same experience as Lankester, all their specimens having been of the male sex (see Boulenger and Flower, 'Proc. Zool. Soc.' 1928, p. 1005).

Volume 21 of the 'Quarterly Journal of Microscopical Science' contains an extraordinary record of original work by Lankester. In addition to an account of his further studies of *Limnocodium*, it includes a notable paper on the appendages and nervous system of *Apus*, and an even more remarkable study of *Limulus* and *Scorpio*. The prevailing opinion among zoologists at that time was that *Limulus*, the King Crab, belongs to the Crustacea, although Lankester fully acknowledged the facts that Straus-Durckheim, in 1829–30, had included it in the Arachnida, that other zoologists had "grudgingly admitted" its affinities in that direction, and that E. Van Beneden, on embryological grounds, had considered it unreservedly an Arachnid. By a masterly comparison with Scorpions, Eurypterines, and Pedipalpi, Lankester demonstrated the detailed "homogeny," in these forms, of the segmentation of the body, the number and characters of the appendages,

the entosternite (an internal skeleton), the nervous system, and other anatomical characters. His original account was followed by others on the same subject, one of them in collaboration with his pupil, (Sir) A. G. Bourne. Although his conclusion that the Trilobites are also to be referred to the Arachnida is not universally accepted, it would be difficult to resist the force of his cogent arguments as to the relationship of the King Crab to the Scorpions, the Arachnids to which he considered that it is most nearly allied.

There are few groups of the animal kingdom which Lankester did not study and elucidate. In consulting his works one expects, and is not disappointed, to find some definite contribution to knowledge based on careful and accurate observation. I cannot find evidence that he ever wrote an original paper on a purely entomological subject; although, as shown by essays published during the latter part of his life, he was fully aware of the interest of this branch of Zoology and of its immense economic importance. In this connexion he speaks of "those patient benefactors of mankind the systematic entomologists" ('Science from an Easy Chair,' 1910, p. 296).

In 1884 Lankester published interesting observations on *Rhabdopleura*, to obtain which he made a special visit to Norway in 1882. During this expedition he discovered *Hamingia*, a new Gephyrean of special interest, since it possesses dwarf males which are parasitic on the female, as in *Bonellia*. *Hamingia* was also shown to be remarkable in the possession of red blood-corpuscles coloured by hæmoglobin. His valuable contributions to the knowledge of *Amphioxus*, made partly with A. Willey, appeared in 1889 and 1890. In 1896 he described for the first time the remarkable villi of the pelvic fins of the male *Lepidosiren* ('Trans. Zool. Soc.' xiv, p. 17). The significance of these structures, which become greatly enlarged during the breeding-season, and are reduced at its close, has excited much interest in view of the question of their probable function. The 'Monograph of the Okapi' was published for him by the Trustees of the British Museum in 1910.

From 1862 to about 1900 Lankester produced a constant succession of original scientific papers. In 1898 he had taken up duties of a new character at the British Museum, and it may be presumed that these left little time for the microscopic observations on which his work had been hitherto based. In any case the former rate of production decreased from about this period. He continued to edit the 'Quarterly Journal of Microscopical Science,' and he was, moreover, occupied with the editing of his 'Treatise on Zoology,' 1900–1909, consisting mainly of substantial contributions by other zoologists. As stated in the Preface to the first volume published (part iii,

1900), the Treatise was addressed to the serious student of Zoology. "A main purpose of the Editor has been that the work shall be an independent and trustworthy presentation, by means of the systematic survey, or taxonomic method, of the main facts and conclusions of Zoology, or, to speak more precisely, of Animal Morphography." The 'Treatise' contains much valuable matter, and it is to be regretted that it was found necessary to discontinue its publication, after the appearance of eight volumes, which by no means cover the whole of the ground, as was originally contemplated.

This second period was occupied mainly in the production of a series of volumes containing essays addressed to the general public. 'The Advancement of Science' had appeared in 1890, and its principal successors were 'Extinct Animals' (1905), 'The Kingdom of Man' (1907), 'From an Easy Chair' (1908), 'Science from an Easy Chair' (2 vols., 1910, 1912), 'Diversions of a Naturalist' (1915), 'Secrets of Earth and Sea' (1920), and 'Things Great and Small' (1922). In these volumes Lankester performed a conspicuous service by explaining many of the results of scientific research in a form which could be appreciated by readers with little previous knowledge of the subjects discussed. His great gift for exposition was employed to the fullest advantage. The essays, many of which had originally appeared in 'The Daily Telegraph,' are models of clear, accurate, and attractive writing, and they must have been read with enjoyment and profit by thousands who would otherwise have had few opportunities of forming any idea of the meaning and objects of scientific research. In the choice of his material Lankester showed extraordinary courage, not limiting himself in any way to Zoology, but writing on all sorts of subjects on which he would hardly have been expected to be able to speak with authority. But, so far as I can judge, the essays in question, like the others, maintain a constant high level.

Where so much is good it is difficult to select the best, but the following essays may be specially mentioned. 'The Advancement of Science' begins with "Degeneration: a Chapter in Darwinism," an evening lecture to the British Association in 1879 which had been published separately in 1880. This admirable essay, elaborating a principle the importance of which had previously been emphasized by Anton Dohrn, should be read by all students of Zoology. "The History and Scope of Zoology," "Pasteur and Hydrophobia," and "Parthenogenesis," in the same volume, are all of the highest merit, and the first of these in particular deserves the close study of Zoologists in general. In his account of 'The Scientific Results of the International Fisheries Exhibition, London, 1883' (*ibid.* p. 215; see also p. 101) Lankester

emphasized the need of a fully-equipped Biological Laboratory on the British coast, indicating the lines on which it should be constructed and the nature of the work it could accomplish. On p. 219 he was able to add an Appendix, showing that the scheme he had already outlined had become a reality. He had taken the steps necessary for calling a Meeting, which was held at the Royal Society in March 1884, with Professor Huxley in the Chair, in order to promote this object. It was then decided to establish the Marine Biological Association of the United Kingdom, of which Huxley became the first President, and H.R.H. The Prince of Wales, Patron. The Association commenced its work by building the well-known Laboratory at Plymouth, the funds which made this possible having been collected mainly as the result of Lankester's persuasive energy. He was at first Hon. Secretary of the Association, and became its President in 1892, an office which he still held at the time of his death. He took the deepest interest in its progress, and its conspicuous success is due largely to his initiative and fostering care. The service he thus rendered to the study of marine Biology and Oceanography in this country has proved very great.

Lankester's article on Pasteur, above referred to, contains additional evidence of the successful influence he was able to exert in matters of great practical importance (*ibid.* p. 164). He was directly responsible for the action of the Lord Mayor (Sir James Whitehead) in summoning a Meeting, which was held at the Mansion House on July 1st, 1889, in order to interest the medical profession and others in Pasteur's work on Hydrophobia. It was declared to be the most influential Meeting which ever assembled at the Mansion House, and it was productive of immediate practical results.

'Extinct Animals' (1909) consists of a course of lectures, adapted to a juvenile audience, given by Lankester during the Christmas holidays 1903–4 at the Royal Institution. It explains some of the elementary principles of Geology required in order to appreciate the facts of Palæontology, and it describes many of the more notable fossil animals, Vertebrate and Invertebrate, known to have existed. At the beginning of his course he stated (p. 4) that "The whole art of education consists in exciting the desire to know." This contains the secret of his eminent success as a teacher, whether by the oral method or by his published works. I myself, in early youth, had the privilege of studying under him at University College. He was, without exception, the most inspiring lecturer to whom I have ever listened. Concise and crystal-clear, illustrating his discourse by skilful drawings, and with every fact fitted into its place to explain some principle, he gave his students an admirable introduction to Zoology, and particularly to its

morphological side. Though, perhaps, we did not fully realize it at the time, he was completely successful in his mastery of the art of education as explained above. The other volumes mentioned breathe the same spirit, and I cannot doubt that there have been many of the readers to whom he addressed his essays who have been infected, as he wished them to be, with the desire to know more. He illustrated the same principle in his own personal relations with Nature, and he was not satisfied with his observation of a fact without trying to ascertain what lesson it could teach, nor with the acceptance of a theory until he could apply some method of testing its accuracy. This desire to look beneath the surface of things had shown itself early in his life, and he describes a characteristic instance in which, when "a very trustful little boy," he had devised a successful experiment for proving or otherwise the statement that birds can be caught by putting salt on their tails ('From an Easy Chair,' 1908, p. 59).

Although he was primarily a morphologist, nothing gave him greater pleasure than coming into contact with Nature, on land or in water. "All beauty of living things, it seems, is due to Nature's selection, and not only all beauty of colour and form, but that beauty of behaviour and excellence of inner quality which we call 'goodness'" ('Science from an Easy Chair,' 1912, p. 17). This was his creed, and the essay on "Switzerland in Early Summer," in which these words occur, reveals the mind of a poet. He was a warm champion of Darwin's Selection theory, and he would have nothing to do with the inheritance of acquired characters. His indignation was frequently expressed at the unnecessary extermination of animals—"the withering blight created by modern man wherever he sets his foot" (*ibid.* p. 379)—and he expressed his special approval of the objects of the Society for the Promotion of Nature Reserves and of the National Trust ('Diversions of a Naturalist,' 1915, p. 17). He had little sympathy with the claims of the supporters of such practices as palmistry and divination. He had personally investigated pretensions of this nature, and had found them wanting. But his attitude in the matter was a perfectly reasonable one: "Lovers of science have never been unwilling to investigate such marvels if fairly and squarely brought before them" (*ibid.* p. 363); and he was of opinion that reluctance had generally been shown to submit marvellous occurrences to the judgment of science.

Lankester attained a high position in the scientific world early in life, and after Huxley's death remained the admitted leader of British Zoologists. He was at his very best as a teacher, not only because of his unrivalled power of exposition, but because he aimed at stimulating the desire to learn and to

participate in the investigation of new problems. Many well-known Zoologists were his pupils, and they were inspired by his example to attempt to follow in his footsteps. His generous appreciation of their efforts, when these were deserving of praise, lives in their grateful memory. He was entirely dominated by the desire to know the truth, and he had no patience with any form of insincerity. He was himself an investigator of the first rank and an enthusiast for research : " To aid in the production of new knowledge is the keenest and the purest pleasure of which man is capable " (' Advancement of Science,' 1890, p. 106). He had an intense love of Nature in all her moods, and nothing gave him so much pleasure as a dredging expedition (although he suffered considerable discomfort from the motion of the boat), or the study of the animals in a rock-pool, a freshwater pond or other natural surroundings. It is not surprising that he was an admirer of Charles Kingsley, the author of ' Water Babies.' His work was accurate and trustworthy, aided by the rare gift of insight, which frequently enabled him to find in common objects some fact or illustration of a general principle which would have been overlooked by a less competent observer. His knowledge of many branches of science and history was extraordinarily wide, extending far beyond the confines of Zoology and Geology, and he used this knowledge with great effect in explaining to the uninstructed some of the objects and results of scientific research. Although he was by nature combative, and was not infrequently alarming to his opponents, his disposition was sympathetic and kindly. He had a great affection for members of his own family and he had many intimate friends, among whom may be mentioned F. M. Balfour H. F. Osborn, Anton Dohrn, H. N. Moseley, Rudyard Kipling, and H. G. Wells. He was devoted to children, of whom he speaks with reverence : " The sentiments of peace and goodwill which belong to Christmas—and, above all, the dedication of many of its customs to children —are things to be cherished and treated tenderly " (' Science from an Easy Chair,' 1910, p. 361).

Lankester's death has left a gap in our ranks which cannot be filled. Among those who mourn his loss are his old pupils who think of him as a revered master whose influence gave a new direction to the whole course of their lives.

SIDNEY F. HARMER.

By the death of Dr. JAMES COSMO MELVILL (1845–1929) the Linnean Society has lost one of its oldest Fellows, for he was elected in 1870, when George Bentham was President of the Society. Cosmo Melvill was born at Hampstead in 1845, the son

of James Cosmo Melvill, Assistant Under Secretary of State for India. While still at school at Harrow, he devoted his attention to the study of Natural History, and with astonishing scientific precocity published in 1864 a Flora of Harrow which ran through several editions. He probably inherited his scientific instincts from his grandfather, Sir James Cosmo Melvill, who was a Fellow of the Royal Society. On leaving Harrow, Cosmo Melvill proceeded to Trinity College, Cambridge, where he graduated in 1868. After graduation, he visited the Continent, collecting on the Rhine and in Switzerland, and thus adding many European to the British plants in his collection. A year's visit to America, 1871–72, during which he travelled widely between Florida and Canada, enabled him to extend his collection to American plants, including a substantial collection of Algæ from the Florida Keys. Mr. Melvill then entered the business of his uncle Mr. Hardcastle, and in 1887 that of Messrs. G. and R. Dewhurst, East India Merchants, of Manchester, with whom he stayed until his retirement in 1904. Being a successful business man, he was able to add largely to his herbarium by the purchase of important collections. Thus he acquired the non-European plants of Dr. Boswell Syme, and a large collection of New South Wales plants named and certified by Sir J. E. Smith, one of the founders of the Linnean Society, being a duplicate set of the Australian collection of his herbarium now in the possession of the Society at Burlington House. On his retirement from business in 1904 Mr. Melvill presented his herbarium to the University of Manchester, in the Museum of which it is now housed. Particulars of the various collections included in this herbarium can be found in publication no. 54 of the Manchester Museum.

Mr. Melvill was, however, not only interested in plants, he was also a great collector of shells, and a member both of the Malacological Society of London and of the Conchological Society of Manchester, of which he was President on several occasions. He was a recognized authority in this subject, and many important collections were entrusted to him for identification and description, as, for instance, the marine mollusca of the Scottish National Antarctic, the Jackson-Harmsworth, and the Torres Straits Expeditions. He published more than fifty papers dealing with the description of new species, frequently in collaboration with the late Mr. Robert Standen, of the Manchester Museum. Even after his retirement to Meole Brace Hall near Shrewsbury, he continued his active work in Conchology, and only last year, at the age of 83, he completed the task of describing the large collection of Mollusca made by Mr. Townsend in the Persian Gulf.

Mr. Melvill's botanical publications were less numerous, but always of interest. He was a contributor to the pages of the

'Journal of Botany,' and not infrequently to the 'Memoirs of the Manchester Literary and Philosophical Society,' of which he was President from 1897 to 1899. The contributions dealt mainly with systematic botany, with geographical distribution, and with new British records.

His eminence as an authority in various branches of Natural History was recognized by the University of Manchester, which awarded him the Honorary Degree of D.Sc. in 1908. Even after his retirement to Shrewsbury, Dr. Melvill, apart from continuing his work in Conchology, interested himself in general Natural History, and became an active member of the Caradoc and Severn Valley Field Club, of which he was for many years the botanical referee, and President from 1904–1914. He had a considerable gift for drawing, and during his retirement he continued to add to a remarkable collection of water-colour drawings of fungi commenced many years before.

During the last few years of his life, though his mind was as clear and as active as ever, his physical health did not enable him to get about easily. He was unable to rally after a severe fall in October which caused an injury to his shoulder, and he died, fortunately without pain, on November 4th, 1929. He will be remembered by those who knew him as a sympathetic friend, ever ready to assist with help and advice, and as a naturalist of extraordinary wide knowledge with an intuitive gift of discriminating species and of fixing upon definite features of difference.

Mr. Melvill married in 1874 the daughter of Mr. G. C. Dewhurst, of Lymn, Cheshire, and in 1924 was able to celebrate his golden wedding after 50 years of unclouded married life. He leaves a widow, four daughters, three of whom are married, and a son, Lt.-Col. Malcolm Melvill.

Apart from his exotic herbarium, which was presented to the Manchester University in 1904, Dr. Melvill left his British and European plants to his old school at Harrow. His large collection of shells he had recently disposed of to Mr. J. R. de Tomlin.

F. E. Weiss.

William Narramore (1850–1930) was born at Totnes on the 6th February, 1850, and died at his home in Waterloo, Liverpool, on the 21st April, 1930. He was elected a Fellow of the Society on the 21st March, 1889, and at the time of his death had completed the forty-first year of his Fellowship. Although early in life he was in the ships' stores business in Liverpool, a passionate love of Nature made him relinquish that and become a science teacher. From 1878 onwards he was lecturing on biology, animal physiology, hygiene, and nature study at various institutions in Liverpool, and at Birkenhead and

Edge Hill. He was President of the Liverpool Science Students' Association, Liverpool Microscopical Society, and Liverpool Naturalists' Field Club, and a member of the Liverpool Biological Society. He made many contributions to the publications of these societies, notably one entitled "A List of the Fresh Lake Algæ of the Liverpool District" ('Trans. Liverpool Biol. Soc.' vol. v, 1891). He was also the author of a book entitled 'Elementary Physiology' (Methuen, 1910). He was specially interested in photomicrography. E. G. N.

The Very Rev. David Paul was born in Aberdeenshire in 1845 and died at Edinburgh on July 12th, 1929. After being at his father's parish school he passed direct to Aberdeen University at the age of 15, carrying off the first bursary. He had a distinguished academic career and gained the Fullerton Scholarship in classics. After twenty years at Roxburgh he was transferred to the important charge of the Robertson Memorial Church in Edinburgh and was Moderator of the General Assembly of the Church of Scotland in 1915, having previously held office as Deputy-Clerk and Principal-Clerk.

Dr. Paul had an interest in Botany generally, but was known chiefly as a mycologist, being prominent amongst the members of the Scottish Cryptogamic Society when the Society was actively engaged in investigating the rich mycological flora of many parts of the country. He was President of the Society for many years and was President of the British Mycological Society in 1918; he also served as President of the Botanical Society of Edinburgh, the Berwickshire Naturalists' Club, and the Scottish Alpine Botanical Club. He visited the West Indies on several occasions in connection with the duties of his church; in 1887 he went to British Guiana to study the vegetation. Dr. Paul became a Fellow of the Society in 1926. He was a man of great charm and erudition.

J. Ramsbottom.

Charles Edward Pearson, V.M.H., F.L.S., F.R.H.S. (1856–1929). Vigorous for his years and delighting in such sports as tennis and skating, it is the more regrettable that Charles E. Pearson lost his life as the result of injury to the ear from a fast-travelling hockey ball. The accident happened many years ago, but alas, his deafness increased, and so he failed to hear an engine, obscured by fog, at the level crossing of a railway station near his home. He was knocked down and never recovered consciousness. And so, tragically, there passed away one, 73 years of age, whose whole business life was devoted to horticulture, for he was one of three brothers who, at Lowdham, developed the business of nurserymen and seedsmen commenced by their forebears at Chilwell. In his

earlier years C. E. Pearson devoted his attention to the cultivation and improvement of florists' flowers—Chrysanthemums, Pelargoniums, Fuchsias, etc., but in later life paid more attention to the cultivation of fruit-trees and vines. He was founder and, until quite recently, also Editor of the 'Horticultural Trades Journal,' and also the founder and for many years Secretary of the Horticultural Trades Association. His fine work on behalf of the nursery trade and his wide knowledge of florists' flowers won for him the V.M.H. Mr. Pearson was a traveller in a modest way, frequently acting as judge at the leading horticultural exhibitions on the Continent—Ghent, Paris, Antwerp, Haarlem, etc. But Mr. Pearson was not only a great horticulturist and a good sportsman; he was also an ornithologist of no mean order, and possessed a handsome collection of birds' eggs collected in the Midland Counties and so far afield as Novaya Zembla and Algeria, and it was probably because of this great interest, rather than because of his horticultural and botanical interests, that he became a Fellow of the Linnean Society in 1904. A keen observer, and therefore a sharp critic on occasion, Mr. Pearson was, despite his deafness, a cheery person with a fine sense of humour; his disability, however, was the chief cause of his infrequent attendance at the meetings of the Linnean Society.

C. H. Curtis.

Alice Marguerite Pegler (1861–1929) was born at Keiskama Hoek, in the Cape of Good Hope, on July 21st, 1861. She was the daughter of S. Mackin and E. Pegler. She was educated at the Dominican Convent, Kingwilliamstown, and in her early days was a teacher. Later on she lived at Kentani with her brother-in-law so that she might bring up and educate his little daughters. She never enjoyed robust health, and all her life long was troubled with her eyes, which would not function properly, but, in spite of great physical drawbacks, her achievements in the field of botany and natural history were remarkable. She produced a valuable catalogue of Kentani plants, amongst which she discovered twenty-eight new species. Apart from this, she interested herself in fungi, beetles, gall-flies, spiders, especially trap-door spiders, and found a new scorpion which bears her name. Her field-notes on Cycads and on the life-history of *Chaliodes Junodi* are perhaps the most noteworthy records of her original work.

Her own herbarium at Kentani contained over two thousand specimens, while she generously supplied many institutions throughout South Africa with representative sets of her plants. Amongst these the National Herbarium at Pretoria has greatly benefited by her labours and generosity. On one occasion the late Professor MacOwan, when told that Miss

Pegler would like some tips on the preparation and management of specimens, said "Tell her she has nothing to learn from me." Growing infirmity but unabated interest caused her in her later years to turn more attention to the collection of fungi and algæ as being easier to handle and deal with, and many bear her name.

Alice Pegler was quite a helpless invalid for seven years before her death. She died at Umtata, in the Transkei, on the 17th June, 1929.

She was the first woman to be elected an Associate of the Linnean Society (in 1912), an honour which she treasured to the end. I. B. Pole Evans.

Wilfrid Robinson (1884–1930). Though he had only been a Fellow for a few years, the Linnean Society has lost, by the death of Wilfred Robinson on March 7th, an eminent botanist who gave promise of a distinguished and brilliant career. Born in 1884 in Hull, his tastes were no doubt developed in the direction of Botany by his father, the late James Fraser Robinson, the author of the 'Flora of the East Riding of Yorkshire.' Wilfrid Robinson was educated in the Central Secondary School in Hull and later at University College, Nottingham, graduating with Honours in Botany in the University College, Nottingham, in 1908. After graduation he taught botany and chemistry, first in the Hull Technical College and then at Penteth School, Warrington. While teaching at the latter school Robinson visited the University of Manchester to commence some mycological researches under the direction of Dr. Lang, and proving himself to be an excellent investigator, he gave up his teaching post for a comparatively small research scholarship, but with the hope that he might ultimately obtain an academic post. Taking the M.Sc. degree on the strength of an excellent mycological thesis, he was appointed in 1914 Assistant Lecturer in the University of Manchester. (Later he took the D.Sc. degree at Manchester.) In 1915 he was promoted to a Lectureship in Economic Botany, and in 1918 he was appointed Senior Lecturer, a post which he held until his election to the Professorship of Botany in University College, Aberystwyth, in 1926. Robinson was an excellent teacher, clear and forceful in the expression of his subject and able to deal with large classes of medical students, being a good disciplinarian. He was a stimulating director of research, largely owing to the energy with which he devoted himself to original investigations; for though heavily burdened with teaching and latterly with administrative duties, he was always anxious to extend botanical knowledge, and did so in many directions. His earlier researches were of a mycological nature. The first of

these, on "The Relations between *Puccinia malvacearum* and the Tissues of its Host-plant," was published in the 'Memoirs of the Manchester Literary and Philosophical Society' (1913), followed by a further one, "On the Effect of External Stimuli on the Sporidia . . ." of the same fungus ('Annals of Botany,' 1914). A paper on the Wilt Disease of Asters appeared in the 'Annals of Biology' (1915).

During the war, Robinson was engaged in carrying out investigations on timbers for the Aeronautical Research Committee, in whose reports several researches were published. The most important scientific outcome of these investigations, published under the title of "The Microscopical Features of Mechanical Strains in Timber, and the Bearings of these on the Structure of the Cell-Wall in Plants," appeared in the 'Philosophical Transactions of the Royal Society' (1920). Though undertaken for applied purposes, it represents a piece of fundamental research, and is very typical of the scientific grasp which Robinson had of first principles.

After the war, Robinson returned to his mycological investigations, publishing an important critical study of Crown Gall ('Annals of Botany,' 1923), in which he demonstrated the unsoundness of some of Erwin Smith's conclusions, and indicated that an essential difference exists between Crown Gall and cancer. Papers on *Sporodinia grandis* and on *Pyronema confluens* appeared in 1926 in the 'Transactions of the Mycological Society' and the 'Annals of Botany' respectively. But Robinson was not wedded to mycological research; he published a good morphological account of the 'Proliferation and Doubling in the Flowers of *Cardamine pratensis*' in 1924, and after his appointment to the Professorship of Botany in Aberyswyth he attacked with characteristic energy some interesting problems connected with the physiology of the development of certain Brown Seaweeds, for the study of which his sound knowledge of plant physiology fitted him. A preliminary account of these investigations was given in December 1930 to the Manchester Literary and Philosophical Society, of which he had always been an active member.

Robinson was a keen field-naturalist and an active member of various botanical societies. For some time he had acted as Secretary to the Botanical Section of the British Association, and attended in that capacity the Toronto meeting in 1924. Those who had been privileged to work with him formed a very high opinion of his capabilities both as a teacher and an investigator. There is no doubt that he would have continued, had he lived, to enrich botanical science with publications of first-rate importance. It is therefore greatly to be deplored that he passed away at the early age of 45 from a heart trouble

brought on by an attack of influenza, leaving a widow and two young children. Those who knew him personally mourn the loss of a sincere friend whose integrity and ever ready help they greatly valued. F. E. Weiss.

Charles Edgar Salmon (1872–1930), who died rather suddenly and unexpectedly on New Year's Day, was born on November 22nd, 1872, and educated privately and at Reigate Grammar School. He was an architect by profession, a member of the Royal Institute of British Architects and of the Architectural Association, and had an extensive practice in Reigate and the neighbourhood.

C. E. Salmon was one of our leading authorities on the British Flora, to the study of which, in the field, he had devoted his leisure from boyhood. The volumes of the 'Journal of Botany' and the Reports of the Exchange Clubs for many years past embody a record of his careful work and critical observation.

He was an active member of our Society, to the Fellowship of which he was elected in 1902. He occasionally exhibited plants, and could be relied on to offer helpful remarks or criticism when communications bearing on the British Flora were before the Society. His paper on "A Hybrid *Stachys—S. digenea* (*S. germanica* L. × *S. alpina* L.)" was published in the Society's Journal in 1919. He served on the Council from 1920–23. He was appointed referee to the Watson Botanical Exchange Club in 1911, and among his other services to British natural history may be mentioned his work for the Holmesdale Natural History Club, of which he was elected President last year; for the South London Botanical Institute, of which he had been a Fellow since 1913; and for the Botanical Section of the South-Eastern Union of Scientific Societies, of which he was President in 1928, when he gave an address on "Fruits and Seeds as a means of distinguishing Allied Plants."

His *magnum opus*, 'The Flora of Surrey,' on which he had been engaged for some years, has been eagerly expected. A large portion of it is already in type, and it is hoped that its completion will be possible from manuscript or notes which the author has left. The second "Supplement" to Watson's 'Topographical Botany,' now appearing as a Supplement of the 'Journal of Botany,' which Mr. Salmon prepared in co-operation with the late Arthur Bennett and Prof. J. R. Matthews, is all in the printer's hands and will shortly be completed.

In his Preface to the Eleventh Edition of the 'London Catalogue of British Plants' (1925), Mr. F. J. Hanbury refers to the great help that he had received from Mr. Salmon: "The preparation has been rendered possible by the willing

and unstinted labour of Mr. C. E. Salmon. It is he who has carried through a laborious piece of work which has made serious inroads on his time during several years. He. too, with my approval and ready assent, secured the services of many of our leading experts in connection with the genera to which they have devoted special study."

C. E. Salmon was a most prolific writer on many genera of our Phanerogamic Flora, as a glance through the volumes of the 'Journal of Botany' and the Reports of the two Botanical Exchange Clubs, for the last 30 years, will readily testify. Perhaps his most important works, the papers by which he will be best remembered, are his figures and descriptions of numerous species of *Limonium* (*Statice*) British and foreign, his papers on *Alchemilla*, and his 'Flora of Surrey.'

His principal work on *Limonium* (*Statice*) may be summarised as follows :—

In the 'Journal of Botany' for 1901 he described and figured *Limomium lychnidifolium* O. K. var *corymbosum*, discovered by Mr. C. P. Andrews on the rocks by the sea in Alderney. The original *lychnidifolium* came from Perpignan and Sainte Lucie (Aude).

In 1903 he described and figured *L. recurvum*, collected by the Rev. H. E. Fox at Portland; owing to the demand for Portland stone this plant is liable to be exterminated. It is the *L. Dodartii* of Babington's Manual, but not of Girard. Also he described *L. occidentale* var. *procerum* from Carnarvonshire : the var. *intermedia* of *L. occidentale* Syme *pro parte*.

In 1904 he described and figured *L. Neumani* (*L. humile* × *vulgare*), discovered by the Revs. E. F. Linton and E. S. Marshall at Bosham, in West Sussex ; also *L. vulgare* Mill. var. *hallandicum* from Sweden and Denmark is figured.

In 1905 he had a careful paper on *L. vulgare* Mill. and its varieties. He considers *Statice drepaninsis* Tineo a Sicilian variety of *L. vulgare*.

In the 'Journal of Botany' for 1908 there is a good figure and description of *Limonium Dubyi* O. Kuntze, a species coming from the South-West of France. It is *Statice dichotoma* Duby *non* Cav.

In 1907 there are notes on *L. Gmelinii* O. K. and its forms and varieties. This species is not confined to the coast as are our British species.

In 1911 there is a figure and description of *L. tomentellum* O. Kuntze, a Russian species, an ally of *L. Gmelinii* O. K., also var. *sareptanum* from Sarepta.

In 1915 *Statice minuta* L. and its varieties are described, a Mediterranean species.

In 1917 *S. asterotricha* is described and figured as a Bulgarian species, an ally of *Gmelinii* Willd. : in 1922 *S. anfracta*, an ally

of *S. remotispicula* Lacaita from Dalmatia; and in 1923 *S. vestita*, an ally of *S. cancellata* Bernh. from Dalmatia.

He also studied most carefully and critically the British forms of the genus *Alchemilla*, and in order to have a closer acquaintance with them he had a collection of them in his garden.

In 1913 he exhibited at one of our meetings a large series of forms coming under *A. vulgaris* L. These were *A. pubescens* Buser, *A. pratensis* Schmidt, *A. minor* Huds. var. *filicaulis* Lindeb., and *A. alpestris* Schmidt.

In 1914 he figured and described *A. acutidens* Buser var. *alpestriformis* from Ben Lawers, and in 1925 he recorded *A. acutiloba* Buser from Goathland, *A. pastoralis* Buser from Aviemore, *A. subcrenata* Buser from Loch-an-Eilan, near Aviemore, *A. tenuis* Buser from Scotland, *A. connivens* Buser from near Dalnaspidal, and *A. firma* Buser from Ben Lawers. *A. glomerulans* Buser was first recorded as a British plant by Mr. Wilmott.

In 1926 Dr. Jacquet named and described *A. Salmoniana* from Cumberland in his honour.

In 1929 Salmon recorded *A. tenuis* Buser from Stevenage, *A. heteropoda* Buser from Forfarshire, *A. acumenatidens* Buser from Aviemore, *A. coriacea* Buser from near Legaston, Forfarshire, and carefully traced the distribution of *A. argentea* Don (*A. conjuncta* Bab.).

The writer was fortunate in having several very delightful botanical excursions with Mr. Salmon. I think it was in 1921 that we went together to Glen Clova, in Forfarshire, and were fortunate in finding most of the rarities for which that locality is so justly celebrated. On our way home we explored what is left of the Moss of Restennet, in hopes of finding some traces of *Eriophorum alpinum* L., found there in the days of Robert Brown, but we were not successful.

Another interesting excursion was to the Lizard in 1926, in company also with Col. Wolley-Dod, and again we were fortunate in finding most of the rarities.

He was a most charming companion, keenly alert to every aspect of our British Flora, and always willing to place the knowledge he possessed at the disposal of others less well versed in the intricacies of some of our segregate species.

Mr. Salmon was much interested in the history of his town and county. He had made a large collection of rare maps of Surrey, which he exhibited at the "Old Reigate Exhibition" in January 1929, in the organisation of which he had played an active part. He had also been for a long time Hon. Secretary of Reigate and Redhill Open Spaces and Footpaths Preservation Society.

Salmon was married on June 29th, 1905, to Miss Agnes Bowyer. His wife, two daughters, and one son survive him.

The funeral took place on January 4th at the Friends' Burial Ground, Reigate; many of his botanical friends expressed their sympathy by their presence.

He will be long remembered not only for his indefatigable industry and work on our British Flora, but also for his charming personality and simple unaffected disposition. His herbarium is left to the National Collection at South Kensington. It also includes the herbaria of Messrs. Arthur Bennett and Henry Tuke Mennell, which he had recently acquired. E. G. Baker.

Thomas Scott, LL.D. (1840–1929), was born in Cupar-Fife on December 2nd, 1840. He received little beyond the usual elementary education of the period. As a young man he was keenly interested in Botany, and while still engaged as a working mason he undertook long excursions in his spare time, ascending many of the higher Scottish mountains in search of sub-Alpine plants to add to his extensive herbarium.

In 1871, while still following his trade, he migrated to Greenock. Here he maintained his interest in Botany for a long time, carrying on well-attended classes in the subject under the Science and Art Department. He joined the Greenock Natural History Society and in time became its Secretary. Close contact with the zoologists of the Glasgow Societies, and more particularly his intimate friendship with David Robertson, "The Cumbrae Naturalist," soon diverted his attention to zoological research, and when the excavation for the James Watt dock at Greenock opened up an extensive continuation of the Clyde Marine Post-Tertiary Deposits, the whole of his spare time was given over to the investigation of the beds of shell-bearing clay. Interesting extensions of knowledge were obtained from these deposits; amongst them was the first perfect specimen (now in the Robertson Museum, Millport) of a post-Tertiary period Crab—a *Hyas*—found between the valves of *Pecten islandicus*. Dr. Gwyn Jeffreys, to whom Scott sent his doubtful Mollusca, in a letter of April 23rd, 1883, says: "Your discoveries in Gravel Park will add a new chapter to the post-Tertiary Mollusca of the West of Scotland."

When these deposits were no longer available he turned his attention almost wholly to the living animals. The land and freshwater Mollusca and then the Ostracoda of Renfrewshire and the adjacent counties were investigated. Dredging facilities, provided through the kindly help of his Greenock shipowner friends, next enabled him to extend his systematic exploration of the marine fauna of the Ayrshire coast into deeper water. A new Ostracod, described by Professor G. S. Brady as *Cytheropteron humile*, was one of the fruits of these dredging trips.

In July 1885 Mr. Scott joined the Fishery Board for Scotland as Assistant Naturalist under Professor J. Cossar Ewart and George Brook at the Marine Laboratory at Tarbert, Loch Fyne. His investigations in Loch Fyne brought to light many interesting Schizopoda and other Crustacea. His early interest in the freshwater species, however, never flagged, and in addition to his official duties he succeeded, by rising in the summer mornings at 3 A.M., in exploring many of the freshwater lochs. This was also his habit in later years, and when the 'Garland' was windbound in harbours he was away hunting in the interior. It was while examining the catch from a marshy patch at the side of Loch Fad, in Bute, that he discovered the unfamiliar freshwater Ostracod identified by Professor Brady and confirmed by Professor Jones as *Cypris browniana* Jones (later established as a new genus, *Scottia browniana* (Jones)), then only known as a post-Tertiary form. Mr. Scott later found this Ostracod in some of the old Scottish lake deposits given him by the Geological Survey for Scotland for examination. A small Ayrshire tarn was the only other place where living specimens were found.

In 1887 Scott was transferred to Edinburgh as Assistant Naturalist on the 'Garland,' then beginning systematic trawling investigations on the East Coast of Scotland. His finds amongst the Entomostraca became so frequent that Brady, unable to cope with the supply, suggested that Scott was well able to begin describing the new species and additions on his own account. He accepted this advice, and from then until 1911 the scientific section of every 'Annual Report of the Fishery Board for Scotland' contained at least one extensive paper on new species, on records of marine research, or on subsidiary investigations of inland freshwater areas.

In 1898 the Laboratory was transferred to the Bay of Nigg, Aberdeen, and Scott continued his labours there, working mainly on the crustacean collections made by the 'Goldseeker' for the Scottish section of the International Investigations. In his spare time he investigated the freshwater lochs around Aberdeen, and usually once or twice a week a visit was paid to the Fish Market to search for fish parasites.

In addition to about forty-five scientific papers in part iii of the 'Annual Reports of the Fishery Board for Scotland,' Scott published between 1887 and 1914 over sixty papers in the 'Proceedings' and 'Transactions' of various Scientific Societies. He compiled the list of the Land, Freshwater, and Marine Crustacea for 'Fauna, Flora and Geology of the Clyde Area,' published in connection with the Meeting of the British Association in Glasgow in 1901. His investigations of the Firth of Forth area were published in 'A Catalogue of the Land, Freshwater, and Marine Crustacea of the River Forth and its Estuary,' by the Royal Physical Society of Edinburgh 1906.

Monographs on the Entomostraca of the Gulf of Guinea and revision of the Copepod Genera *Ectinosoma* and *Bradya* were published in the 'Transactions of the Linnean Society.' The Entomostraca of the Scottish National Antarctic Expedition appeared in the 'Transactions of the Royal Society, Edinburgh.' In collaboration with his son Andrew his contribution to our knowledge of the British Parasitic Copepods was issued as one of the Ray Society's series of Monographs.

Scott early came in contact with such men as Professor Brady, Canon Norman, Rev. T. R. R. Stebbing, and for many years he corresponded with Professor G. O. Sars. He was a corresponding member of a number of scientific societies, and in recognition of his services to Science he was presented with a life membership of the Linnean Society in 1889, and in 1903 the University of St. Andrews conferred on him the Honorary Degree of LL.D.

Dr. Scott was a born naturalist and one of Nature's gentlemen; his kindly spirit and retiring disposition endeared him to a wide circle of friends.

In 1866 he married Jean Macandrew, of Styx, Kenmore, Perthshire, by whom he had two sons and three daughters. His son, Andrew Scott, M.Sc., who followed in his father's footsteps and collaborated with him, is now engaged at Liverpool University.

After his retirement Dr. Scott maintained the keenest interest, even under the handicap of failing eyesight. His last two years were passed very quietly, and the end came on 25th February, 1929, after a very short illness. A. Bowman.

Martin Hubert Foquett Sutton, the eldest son of Martin John Sutton and the eldest grandson of Martin Hope Sutton, the founder of the Reading firm, was born on November 28th, 1875.

He was educated at Harrow and Christ Church, Oxford. Shortly after coming down from the University in 1895, he made a nine months' tour of South Africa, Australia, New Zealand, Tasmania, and Ceylon, after which he became a partner in the firm of Sutton & Sons in 1897.

Mr. Sutton married in 1899 Eleonora, daughter of the late Colonel Morton, Commandant of the Border Regiment, by whom he is survived, as also by two sons and three daughters, the eldest of the former being a partner in the firm.

Mr. Sutton was elected a Fellow of the Linnean Society in 1909, and his last attendance at a meeting of the Society was on March 6th last, when his brother, Mr. E. B. Foquett Sutton, was formally admitted a Fellow. He was also a Governor of the University of Reading, and a Fellow of the Royal Geographical Society, the Royal Society of Arts, a member of the Council of the Smithfield Club and Farmers' Club, and a

member of the Duke of Portland's Executive Committee for the Agricultural Relief of the Allies.

One of his first contributions to applied botanical science was a paper on "The Best Grasses for Lawns, Putting Greens, and Golf Courses," read before the Royal Horticultural Society in 1906. He recently edited a new edition of his father's treatise on 'Permanent and Temporary Pastures,' which for a long time has been a standard work on the subject.

Mr. Sutton devoted much attention to the selection and breeding of improved species of grasses and clovers, the results of his researches being embodied in 'Bulletins' issued by the firm of Sutton & Sons. Among the most notable of the series are those dealing with Red Clover, published in 1925–29, and two on the raising of seedling hybrid potatoes and varieties immune to wart disease respectively.

Mr. Sutton was a member of the Potato Advisory Committee of the Ministry of Agriculture. He also received a Certificate of Recognition by the Belgian Government for his work on the Relief of Allies Committee for the agricultural reconstruction of the devastated areas in Belgium and France.

Mr. Sutton manifested a keen interest in the multifarious scientific problems which are continually emerging in the course of the activities of a firm of world-wide connections, and the establishment of a centre at their Langley grounds, near Slough, for the prosecution of investigations into the scientific and agricultural importance of both wild and cultivated varieties and forms of the Gramineæ and Leguminosæ was chiefly due to his initiative.

Mr. Sutton's sincerity and urbane, courteous manner endeared him to all with whom he came in contact, and his presence at the annual gatherings of visitors invited to inspect the researches in progress at Langley will be greatly missed.

JOHN PERCIVAL.

HAROLD W. T. WAGER (1862–1930) in 1888 came North upon his appointment as Demonstrator in Biology in the Yorkshire College at Leeds. Since that date, although he has not always resided at Leeds, he has been so much identified with both science in Yorkshire and with the Yorkshire College—and subsequently the University of Leeds—that he is generally recognized as one of the most distinguished of a very remarkable band of scientific naturalists of the county of the broad acres.

In 1894 he married Winifred Miall, the only daughter of Professor L. C. Miall, the first and only Professor of Biology in the Yorkshire College.

On the outbreak of war, with the consent of the Board of Education, Dr. Wager voluntarily undertook the direction of the Department of Botany during the absence of Professor

Priestley upon war service. After the Armistice Dr. Wager remained for some time in contact with the Department, in which he held an Honorary Lectureship, and it was with regret that the University Council recently received his resignation of that post when he found himself unable to keep in touch with the activities of the Department.

Through his early association with Dr. D. H. Scott, some of Wager's earliest scientific papers were upon plant anatomy, including a paper, in collaboration with Dr. Scott, upon the floating roots of *Sesbania aculeata* : but throughout his career Wager showed a catholic diversity of interest, every subject open to experiment and observation in the scientific spirit being of appeal to a man with the temperament of the naturalist and observer and the training and technique of the student of science.

He first established his scientific reputation by a long series of papers upon the cytology and life-history of the fungi, which were published during the years 1889–1900. Early in the new century he was also making observations upon the cytology of the blue-green algæ, the Cyanophyceæ : but what distinguished Wager as a student of such specialist problems was that he never lost interest in the growing plants in the field. As a result his specialist studies of these two groups have the very unusual accompaniment that he has published in ' The Naturalist ' keys to the determination of species of *Oscillatoria* and *Phormidium*, and also a very useful guide to the determination of genera of the Agaricaceæ.

This interest and sympathy with the field of work of the naturalist, coupled with his specialist knowledge of technique in fields usually outside the naturalists' province, made Wager a great influence in deepening and extending the contribution of Yorkshire naturalists to biology. Under his chairmanship the annual mycological forays of the Yorkshire Naturalists' Union have done very successful work in promoting interest in these plants and in adding to our knowledge of the Yorkshire species. In 1913, as President of the Union, he devoted his address to a brief *résumé* of his observations upon the movements of free-swimming micro-organisms, a fascinating subject which showed him at his best, alike as a naturalist and as a brilliant manipulator of microscopic living organisms, alive to the fact that the infinitely small amongst living creatures have to obey physical laws.

On the occasion of the meeting of the Yorkshire Naturalists' Union in Leeds in 1914, the University conferred upon him the Honorary Degree of D.Sc. in recognition of his great contribution to science and his distinguished association with the study of natural science in Yorkshire. In 1904 he had been elected a Fellow of the Royal Society.

Dr. Wager's severance from academic laboratories, upon his appointment as one of H.M. Inspectors of Secondary Schools, in no way diminished his scientific activity. With simple laboratory appliances, but with an almost uncanny flair for microscopic manipulation, he continued to carry out observations in various fields of biology, and in particular turned his attention to a number of problems of plant physiology. His photographs through the lenses of the leaf epidermis were as beautiful a demonstration of the capacity these cell-wall structures showed to focus objects as his experiments were to show that Haberlandt's views as to the function of these "ocelli" needed revision. He also made numerous observations upon the leaf pigments and other plant pigments, many of which, probably, have never been fully embodied in his published writings.

These unremitting scientific labours were a daily accompaniment to his conscientious fulfilment of his duties as a H.M.I. The result was, naturally, that the teacher of biology in the school, apt to have recourse to the easier path of instruction through text-book and diagram, was constantly being reminded of the wide gap that may exist between the formal description and the object awaiting the unprejudiced regard of the observer. Just as the amateur naturalist, seeing in Wager a kindred spirit, was led by his example to take more pains and extend the range of his scientific technique, so the professional teacher was encouraged to leave routine repetition of secondhand facts, to observe for himself, to become, in fact, a naturalist, and thus to develop a new enthusiasm which rapidly communicated itself to his pupils.

During Wager's long association with Yorkshire he learnt to love the Yorkshire dales. It was in his cottage in Lyttondale that he died on November 17th after a short illness, and he was laid to rest in the little churchyard at Arncliffe amongst associations that were always dear to his memory and to those of his many Yorkshire friends.

There they will like to think of him—at rest in surroundings that were always congenial to his spirit. J. H. Priestley.

Sir George Watt (1851–1930) was born at Old Meldrum, Aberdeenshire, on April 24th, 1851, and after an education in Aberdeen, with one year in Glasgow, graduated M.B. and C.M. in 1873 at the latter University. He had served before graduation as a class assistant to Professor George Dickie in Botany in Aberdeen, and had been appointed prosector to the Professor of Anatomy (Allan Thomson) in Glasgow, when Sir Joseph Hooker nominated him at the India Office for the new post of Professor of Botany in the Presidency College, Calcutta. He accepted the last and arrived in Bengal in

November, 1873. The beginning of his Indian career was to him intensely disappointing, for he found himself a pawn in the battle which science had for some time been fighting for recognition as an educational subject, and his patron, Sir George Campbell, then Lieutenant-Governor of Bengal, who believed that chemistry and botany should be taught on account of their bearing upon the material prosperity of India, unexpectedly retired in the first half of 1874, leaving him at the mercy of those who held to the opposite view. Watt never taught in Calcutta, but was offered as an alternative to his professorship a place in the Bengal Education Department, and was sent to take such duties as he was fitted for in the college at Hughli.

Moreover, there were further disappointments in store for him. Encouraged by the Government he wrote as a class-book his ' First Steps in Botany,' and published it, after translation in Bengali, in 1876 (356 pp. and 242 text-figures) ; but there were no buyers for it. Then in 1877 he followed it with a smaller book written for mission colleges, entitled ' Lessons in Elementary Botany,' which failed to please. Yet these disappointing years of teaching were invaluable to him, for in them he came to know the plants of Bengal, and, obedient to the intention of his initial appointment, their uses. He planned a third book to deal with economic plants, but the reception of the first discouraged him from proceeding with it.

A vacation journey in 1879 in the North-Western Himalaya to the sources of the Bhagra River led to a paper " On the Vegetation of Chamba State and British Lahoul " (' Journ. Linn. Soc., Bot.' xviii, 1881, pp. 368–381, with 5 plates), and another (in 1881) in Sikkim to the slopes of Jongri led to a paper " On some Undescribed and Imperfectly Known Indian Species of *Primula* and *Androsace* " (' Journ. Linn. Soc., Bot.' xx, 1884, pp. 1–18, with 18 plates).

It now seemed to him that botanical exploration offered a way out of the rut ; and in the next two years he applied to the Government for attachment to four different expeditions. His first application was successful, and he went with the Burma-Manipur Delimitation Commission as a medical officer, with permission to use the opportunity for collecting. A paper on " The Aboriginal Tribes of Manipur " (' Journ. Anthropol. Inst.' xvi, 1887, pp. 346–370, with 2 plates) resulted ; but he never completed the working up of his botanical collections, for he was caught in the web of Government machinery in another way, and devoted to the organisation of exhibitions of the resources of India. He had several gifts which marked him out for such employment : he was most methodical, quick to appreciate the popular aspect of any object or process, and, above all, immensely energetic. His

genius for method had caused him to devise during these years of botanical collecting the field-books, each of one hundred numbered sheets with detachable tag-labels for the specimens, which are now so widely used, not only in the East, but by many who collect elsewhere. He continued to use them throughout his Indian career, and at the end of it the current numbering had exceeded 9000.

His first exhibition was the Calcutta Exhibition of 1883–1884. He himself asked for employment in it, and was put in charge of the Economic Court, with orders to use as far as he could the already local resources, including the neglected specimens of a small " Bengal Economic Museum " got together by Sir George Campbell, and to collect from the whole of India something representative of its produce. He threw his energy into the work, and by a great effort compiled in a few months his ' Economic Products of India ' (over 1700 pages), which served at once as an indent upon the Provinces and States, a scheme for arranging the Court, and its catalogue. Watt's position was made by this effort. His genius as a showman and his will to work were recognized ; and he was taken into the Department of Revenue and Agriculture of the Government of India, which was then being built up under Sir Edward Buck.

Watt's next duties were two : (i) to prepare for the Colonial and Indian Exhibition in London, 1886, and (ii) while waiting for it, to elaborate his ' Economic Products of India ' into a ' Dictionary of the Economic Products of India.' He contrived to have the first volume of the latter on sale at the Exhibition, and next wrote his ' Review of the Resources of British India.'

For services to this date he was made a C.I.E., and appointed Reporter on Economic Products to the Government of India. Then he completed the ' Dictionary ' (5269 pages) and edited material which could not be put into the ' Dictionary ' at once, as ' Selections from the Records of the Government of India, Revenue and Agricultural Department,' 1887 and 1888, ' Notes on Indian Economic Products,' 1888 and 1889, and from 1892 forward the ' Agricultural Ledger.' Critics of the ' Dictionary,' who have complained that they do not find evaluations of products in it, must remember that he had orders to compile and not to review.

His new appointment brought opportunities for travel, and he toured the cotton and tea districts. Fruits of these tours were his ' Blights and Pests of the Tea-plant ' (1898), his report on Ramie (' Agric. Ledger,' 1898) and, much later, his ' Wild and Cultivated Cottons of the World ' (1907).

His third exhibition was the permanent Economic Court of the Indian Museum, Calcutta, which was opened to the

public in 1900. Meanwhile, as the ' Dictionary ' had been sold out, plans for revision were discussed, and a decision reached that an abridgement discussing the commercial products only should be prepared. Watt commenced the writing of this early in 1901, but was called away at once to organize the Delhi Exhibition of Indian Art. Time pressed. The few articles already written were transferred to the ' Agricultural Ledger ' (nos. 2–6 of 1901), and Watt, with a small staff, in eight very strenuous months, got the exhibition together. His reward was his Knighthood. After the Exhibition his ' Indian Art at Delhi ' appeared (546 pages, with 87 plates), and he left India for London.

During a little leisure he now bent his attention again to systematic Botany, writing his " Primulas of India " (' Journ. Roy. Hort. Soc.' xxix, pp. 295–326, with 6 plates), and studying *Gossypium* : then he put in five years of work at Kew upon the ' Handbook of the Commercial Products of India,' which appeared in 1908—the last of his contributions towards the material welfare of the country of his service.

His ' Wild and Cultivated Cottons of the World ' had appeared in 1907. The critics were somewhat severe towards it ; but the book is justified as a contribution towards the ultimate analysis of this extremely difficult genus. An insistence upon types is its most important and most useful feature.

Sir George Watt, after a trip to San Thomé, off the Guinea coast, to study cacao, settled at Lockerbie, Dumfriesshire. He had given his herbarium, in 1892, to the University of Edinburgh, and in retirement now renewed his connection with that University, being appointed lecturer for five years on Indian trees to the Forestry students. He devoted his last years to local affairs, and was on the County Council, on the Education Authority for Dumfriesshire, a Justice of the Peace, a member of the Lockerbie School Management Committee and of the Committee of the Crichton Royal Institution in Dumfries.

He died on April 2nd, 1930, at Lockerbie, having been a Fellow of the Linnean Society for 56 years. I. H. Burkill.

BENEFACTIONS.

LIST *in accordance with Bye-Laws, Chap.* XVII. *Sect.* 1, *of all Donations of the amount or value of Twenty pounds and upwards, received during the past Twenty years.*

1910.

Royal Society: Grant towards Dr. G. H. Fowler's paper on Biscayan Ostracoda, £50.

Sir Joseph Hooker: Gold watch-chain worn by Robert Brown, and seal with portrait of Carl von Linné by James Tassie.

Prof. J. S. Gardiner: Payment in aid of illustrations, £35 0*s.* 6*d.*

Sir Frank Crisp: Donation in Trust for Microscopical Research, £200.

The Trustees of the Percy Sladen Memorial Fund: Third grant towards publication of Prof. Stanley Gardiner's Researches in the Indian Ocean, £200. (For third volume.)

1911.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the third volume on the Indian Ocean Researches, £70.

The same: First Donation towards the fourth volume, £130.

1912.

The Indian Government: Contribution towards the illustration of Mr. E. P. Stebbing's paper on Himalayan *Chermes*, £46 15*s.* 2*d.*

The late Mr. Francis Tagart, £500 free of Legacy Duty.

The late Sir Joseph Dalton Hooker, O.M., G.C.S.I., £100 free of Legacy Duty.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the fourth volume on the Indian Ocean Researches, £140.

The same: First Donation towards the fifth volume, £60.

1913.

Royal Society: Grant towards Dr. R. R. Gates's paper on Mutating *Oenotheras*, £60.

Sir Frank Crisp, Bt.: Wallichian Cabinets, £50.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the fifth volume, £200.

1914.

Royal Society: Grant towards Miss Gibbs's paper on the Flora of British North Borneo, £50.

Miss Foot: Cost of illustration of her paper on *Euschistus*.

The Trustees of the Percy Sladen Memorial Fund: Third Donation towards the fifth volume, £10.

The same: First Donation towards the sixth volume, £190.

1915.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the sixth volume, £80.

Miss Foot: Cost of second paper on *Euschistus*, £32 10*s*.

Royal Society: Donations towards the cost of a paper by Mrs. Arber, D.Sc., £40.

The same: towards paper on Utakwa River plants by Mr. H. N. Ridley, C.M.G., F.R.S., £50.

Miss Marietta Pallis: Instalment of cost of her paper on Plav, £30.

Thomas Henry Riches, Esq.: Dr. A. R. Wallace's library on Natural History.

Sir Frank Crisp, Bt.: New shelving for Wallace's Volumes.

1916.

Mr. E. Heron-Allen: Contribution to cost of paper on Foraminifera of N.W. Scotland, £44.

Messrs. H. Takeda and C. West: Contribution towards the illustration of their paper, £40.

Royal Society: Contribution towards the illustration of two papers by Prof. Dendy, £40.

The same: Contribution towards Mr. Swynnerton's paper on Form and Colouring, £70.

The High Commission for the Union of South Africa, per Dr. J. D. F. Gilchrist, for the illustration of his paper on *Jasus Lalandii*, £30.

Miss Marietta Pallis: Balance of cost of her paper on Plav, £90 16*s*. 6*d*.

Sir Frank Crisp, Bt.: Phototyped copy of Dioscorides from the 'Codex Aniciæ Julianæ' at Vienna.

1917.

British Ornithologists' Union, etc.: Contribution towards cost of Mr. H. N. Ridley's paper, £20.

The Royal Society: Second contribution towards the printing of Mr. C. F. M. Swynnerton's paper on Form and Colouring, £75.

Sir Frank Crisp, Bt.: 'Lindenia,' Ghent, 1891–1901. 17 vols. sm. fol.

1919.

Dr. B. Daydon Jackson: MS. index to Linnean Society's Journal, Botany, vols. xxi.–xl. (1884–1912) and the Botanic entries in the 'Proceedings' for the same period.

1920.

The Royal Society: Third contribution towards the printing of Mr. C. F. M. Swynnerton's paper as above, £50.

The High Commission for the Union of South Africa, for the printing of Dr. J. D. F. Gilchrist's paper on *Jasus Lalandii*, Part II., £60.

1921.

The Percy Sladen Memorial Fund: Additional Grant in aid of publication of 'Transactions,' 2nd ser., Zoology, vol. xvii. part 4, £72 10*s*.

The same: Grant in aid of publication of four papers on the Houtman Abrolhos Islands, £100.

The Royal Society: Donation in aid of papers by Mr. N. E. Brown and Mr. S. L. Moore, £90.

Dr. W. Rushton Parker: Donation of a large series of portraits of Naturalists and Persons after whom Genera have been named, and work on rearrangement and annotation of the entire collection.

Prof. C. S. Sargent, F.M.L.S.: Eight volumes issued by the Arnold Arboretum including "The Bradley Bibliography."

Dr. B. Daydon Jackson: MS. Catalogue of each sheet in the Linnean Herbarium; bound in two volumes folio.

1922.

The late Sir Joseph Hooker: Donation of his Medals and Decorations. (Reversion to Linnean Society on Lady Hooker's decease.)

Anonymous donation in aid of publication of the late Dr. E A. Newell Arber's paper, entitled "Critical Studies of Coal-Measure Plant-impressions," £60.

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd. ser., Zoology, vol. xviii. pt. i.

1923.

Dr. W. Rushton Parker: (1) Donation of Oxford New English Dictionary; vols. i.–ix., vol. x. in parts, 4to, 1888–1923. (2) Encyclopædia Britannica; ed. XI. Cambridge, 1920–22. 32 vols. 4to.

E. Heron-Allen, Esq., F.R.S.: Contribution of £25 towards the cost of paper on the Foraminifera of Lord Howe Island.

1924.

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd. ser., Zoology, vol. xviii. pt. ii.

1925.

An Anonymous Donor: New Presidential Chair, emblazoned with the Arms of the Society.

1926.

Subscription portrait of Dr. B. D. Jackson, R.N.O.

Mr. A. D. Michael: A large number of Books and Pamphlets from his Library.

The late Mr. A. O. Walker: £200 free of Legacy Duty.

An Anonymous Donor: £100 to establish a Fellowship in memory of the late Prof. E. A. Minchin, F.R.S., Sec.L.S.

The Royal Society: Donation in aid of publication of Mr. G. P. Farran's paper on Biscayan Plankton.—Part 14. The Copepoda, £60.

The late Mr. Frank Morey: £100 free of Legacy Duty.

The late Mr. George Lewis: Books and pamphlets on Entomological subjects.

Capt. E. G. Spencer-Churchill: A copy of a collotype reproduction of 'The herbal of Apuleius Barbarus . . . (MS. Bodley 130).'

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd ser., Zoology, vol. xix. pt. i.

1927.

The late Mrs. Mary Anne Stebbing: £100 less Legacy Duty.

1928.

Carnegie United Kingdom Trust: £666 13*s.* 4*d.* for purchase of books.

The Royal Society: £160 (£85 in aid of the publication of Dr. G. Enderlein's paper on "Die Copeognathen der Seychellen," £75 in aid of Mr. C. V. B. Marquand's paper on "The Botanical Collections made by Capt. F. Kingdon Ward in the Eastern Himalaya and Tibet in 1924–25").

1929.

Carnegie United Kingdom Trust: £666 13*s.* 4*d.* for purchase of books.

The Percy Sladen Memorial Fund: £100 in aid of the publication of papers on the Fauna of the Paraguayan Chaco.

Carnegie Trust for the Universities of Scotland: £28 in aid of the publication of papers on the Fauna of the Paraguayan Chaco.

1930.

Carnegie United Kingdom Trust: £666 13*s.* 4*d.* for purchase of books.

An Anonymous Donor: £23 towards the purchase of an Epidiascope.

The Royal Society: £100 in aid of the publication of Mr. H. W. Pugsley's paper "A revision of the British Euphrasiæ" and Dr. T. A. Sprague's paper "The Herbal of Leonhart Fuchs."

Mrs. B. Daydon Jackson (the late): valuable reversion under her Will after three life-tenants shall have died.

Mr. B. B. Woodward (the late) and Mr. A. S. Kennard: a portion of Mr. Woodward's scientific library and reversion of the remainder.

TREASURER'S ACCOUNTS FOR THE

(Presented at the Anniversary

Receipts and Payments of the Linnean Society

General

RECEIPTS.	£	s.	d.	£	s.	d.
To Balance at 1st May, 1929	151	4	5			
Do. deposits, Fellows' postal account	66	6	8			
„ Cash in hand	11	16	9			
				229	7	10
„ Admission Fees				60	0	0
„ Arrears of Annual Contributions	37	0	6			
„ Annual Contributions for year	2508	0	0			
Do. in advance	100	0	0			
				2645	0	6
„ Interest on Investments (including Income Tax recovered)				424	5	1
Do. Deposit				28	6	4
„ Sales of Publications:—						
Transactions	50	9	10			
Journals	128	15	7			
Proceedings	9	19	6			
Library Catalogue	9	1	7			
				198	6	6
„ Donations in aid of Publications				147	0	0
„ Donation for General Purposes				1	0	0
„ Fellows' postal account, deposits				14	14	9
„ Miscellaneous Receipts				25	1	10
				£3773	2	10

Library

RECEIPTS.	£	s.	d.
To Balance 1st May, 1929	37	2	5
„ Interest on Investments (including Income Tax recovered)	60	7	5
„ Carnegie United Kingdom Trust—one half of last Third of £2000 Grant	333	6	8
„ Transferred from General Account	316	13	4
	£747	9	10

YEAR ENDED APRIL 30TH, 1930.

Meeting, May 24th, 1930.)

from May 1st, 1929, to April 30th, 1930.

Account.

PAYMENTS.	£ s. d.	£ s. d.
By House Expenditure:—		
Coal	50 6 3	
Electric Current £28 9 8		
Electrical Repairs 26 3 5		
	54 13 1	
Furniture	110 15 0	
Gas	33 2 2	
Repairs, sundry	15 12 11	
Sundry payments	33 1 7	
Taxes and Insurance	35 8 5	
Tea at Meetings	34 9 5	
		367 8 10
„ Linnean Collections: Repairs		51 17 2
„ Office Expenditure:—		
Miscellaneous Printing	133 0 3	
Postages and Sundry Expenses	166 2 6	
Stationery	43 7 10	
		342 10 7
„ Publications:—		
Printing	495 2 9	
Illustrations	81 10 8	
Distribution	57 5 3	
		633 18 8
„ Salaries and Wages, etc.		1053 12 8
„ Transferred to Library Account	.....	316 13 4
„ „ „ Goodenough Fund	.....	5 0 0
„ Zoological Record: Donation for 1929 volume	.....	25 0 0
„ Purchase of £250 3½ per cent. Conversion Stock (Staff Pension Fund)	.....	184 3 6
„ Lamarck Memorial Fund Donation	.....	5 5 0
„ Linnean Medal	.....	15 0 0
„ Fellows' postal account	.....	10 15 5
„ Balance at 30th April, 1930	675 8 0	
Do. Fellows' postal account deposits	70 6 0	
„ Cash in hand	16 3 8	
		761 17 8
		£3773 2 10

Account.

PAYMENTS.	£ s. d.
By Books	126 6 11
„ Periodicals	355 6 9
„ Binding	220 17 0
„ Balance of 30th April, 1930	44 19 2
	£747 9 10

Separate Account.

	£	s.	d.		£	s.	d.
To Balance at 1st May, 1929:—				By Westwood Fund:—			
Westwood Fund £45 4 10				Grant for Illustrations in the Society's Publications	4	3	0
Trail Award Fund 13 14 2				„ Hooker Lecture Fund:—			
Crisp Award Fund 16 14 7				Cost of Printing 1928 Lecture	19	0	0
Hooker Lecture Fund 60 18 8				„ Goodenough Fund:—			
Goodenough Fund 4 15 8				Transferred to Annual Contributions £12 0 0			
Linnean History Fund..... ... 21 9 6				Purchase of £100 Metropolitan Water Board 3 per cent. "B" Stock 63 5 6			
	162	17	5		75	5	6
„ Goodenough Fund:—				„ Minchin Fellowship Fund:—			
Donations £78 7 0				Transferred to Annual Contributions	4	0	0
Transferred from General Account 5 0 0				„ Staff Pension Fund:—			
	83	7	0	Purchase of £4 8s. 9*d.* 3½ per cent. Conversion Stock	3	10	0
„ Interest on Investments (including Income Tax recovered):—				„ Balance at 30th April, 1930:—			
Westwood Fund £11 13 0				Westwood Fund £52 14 10			
Trail Award Fund 3 10 0				Trail Award Fund 17 4 2			
Crisp Award Fund 7 10 0				Crisp Award Fund 24 4 7			
Hooker Lecture Fund 25 3 1				Hooker Lecture Fund..... 67 1 9			
Goodenough Fund 8 7 2				Goodenough Fund 21 4 4			
Minchin Fellowship Fund 5 10 0				Linnean History Fund..... 21 9 6			
Staff Pension Fund 3 10 0				Minchin Fellowship Fund 1 10 0			
	65	3	3		205	9	2
	£311	7	8		£311	7	8

General Account.

£	s.	d.			Market Value, 30th April, 1930. £	s.	d.
1000	0	0	Metropolitan 3 per cent. Stock 1941	@ 86	860	0	0
1200	0	0	India 3 per cent. Stock	@ 54	648	0	0
1000	0	0	Eastern Bengal Railway 4 per cent. Irredeemable Debenture Stock	@ 69¼	695	0	0
1000	0	0	Great Western Railway 4 per cent. Debenture Stock	@ 83	830	0	0
312	0	0	London Midland & Scottish Railway 4 per cent. Preference Stock 1923	@ 68	212	3	2
3296	0	0	4½ per cent. Conversion Stock 1940–44	@ 98	3230	1	7
					£6475	4	9

Library Account.

£	s.	d.			£	s.	d.
450	0	0	Forth Bridge Railway 4 per cent. Stock (Bentham Bequest)	@ 79	355	10	0
200	0	0	4½ per cent. Conversion Stock 1940-44 (Walker and Morey Bequests)	@ 98	196	0	0
530	0	0	East Indian Railway 3½ per cent. Debenture Stock (Tagart Bequest)	@ 61	323	6	0
88	9	8	London County 5 per cent. Stock 1940–60 (Stebbing Bequest)	@102	90	5	0
					£965	1	0

Separate Account.

£	s.	d.				£	s.	d.
£1012 9 5	232	5	0	Metropolitan Water Board 3 per cent. "B" Stock (Westwood Fund)	@ 66	153	5	8
	638	4	5	Ditto ditto (Hooker Lecture Fund)	@ 66	421	4	6
	142	0	0	Ditto ditto (Goodenough Fund)	@ 66	93	14	5
	100	0	0	New South Wales 3½ per cent. Stock, 1930–50 (Trail Award Fund)	@ 70½	70	10	0
	300	0	0	2½ per cent. Consolidated Stock (Crisp Award Fund)	@ 54¼	162	15	0
£200 0 0	50	0	0	4 per cent. Victory Bonds (Westwood Fund)	@ 93⅛	46	15	0
	50	0	0	Ditto ditto (Hooker Lecture Fund)	@ 93½	46	15	0
	100	0	0	Ditto ditto (Goodenough Fund)	@ 93½	93	10	0
	100	0	0	London County 5 per cent. Stock 1940–60 (Minchin Fellowship Fund)	@102	102	0	0
	254	8	9	3½ per cent. Conversion Stock (Staff Pension Fund)	@ 76¾	195	5	8
						£1385	15	3

HORACE W. MONCKTON, *Treasurer.*

We have (in conjunction with the Professional Auditor, who certifies as to all details) audited the Accounts of the Society for the year ended 30th April, 1930, and found them correct. We have verified the Investments and Bank Balances.

Dated this 13th May, 1930.

W. B. KEEN, *Chartered Accountant.*

W. T. CALMAN,
I. HENRY BURKILL,
FRANCIS DRUCE,
D. J. SCOURFIELD,
J. RAMSBOTTOM,
} *Auditors.*

ADDITIONS AND DONATIONS

TO THE

LIBRARY.

1929–1930.

Note.—Separate copies of papers which are included in periodicals received by the Library are no longer catalogued. Names of donors are given in square brackets. The sizes are given in centimetres,—to the nearest centimetre.

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PRINTED BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

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